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LOBECTOMY OF THE LIVER

REPORT OF THREE CASES

KENNETH L. PICKRELL, M.D., AND RICHARD C. CLAY, M.D.*

DURHAM, N. C. BALTIMORE

Resection of large lesions of the liver is a relatively rare surgical procedure, and many surgeons are never called on to perform it. Though by far the commonest large resectable hepatic lesion is hemangioma, Shumacker,[1] in reviewing all the cases from the world's literature to 1942, found only 56 cases in which operation was performed and noted that no author had reported more than a single case. Nevertheless, any surgeon may unexpectedly be confronted with such a lesion, for the correct diagnosis was made preoperatively only twice among the 56 cases reported by Shumacker. Resection of the liver has been performed for such diverse conditions[2] as angioma, echinococcus cyst, gumma, tuberculoma, trauma, carcinoma, sarcoma, adenoma and hamartoma. The surgeon's stock of procedures should, therefore, include methods for excising large segments of the liver. It is for this reason that the present 3 cases, which demonstrate a technic for relatively bloodless resection of the entire left lobe of the liver, are reported.

The two original cardinal objections to resection of large segments of the liver were the severe hemorrhage entailed by transection of this vascular, friable tissue which retains sutures so poorly, and the fear that the function of the liver subsequently would be impaired. The latter objection was largely overcome by the studies of Turner[3] in 1923, when he found the function to be perfectly normal after removal of an adenoma and a large adjacent mass of hepatic tissue weighing 2 pounds 3 ounces (992.23 Gm.). It has become generally accepted that the liver has such an enormous reserve functional capacity that huge areas of it may be destroyed by disease before hepatic function is clinically impaired. But the problem of hemostasis in resection of the liver remains the major one.

Turner[3] in 1923 summarized the methods which had been employed to effect hemostasis in operations on the liver under the following heads: (*a*) compression of the vessels in the free edge of the lesser omentum, (*b*) manual pressure on the hepatic substance at the edge of the wound, (*c*) placing of clamps across the liver, (*d*) use of an elastic tourniquet and (*e*) use of the cautery. A glance at some of the reported cases in which the procedure is described provides examples of these means. It will be noted that in general among the earlier cases the mass to be removed was extraperitonealized, while in later reports the operation was usually entirely intraperitoneal.

In 1897 von Rosenthal[4] reported a pedunculated angioma of the left lobe of the liver treated by transfixing the base with knitting needles. He brought these out on the abdominal wall, tied an elastic tourniquet on the hepatic side of them for hemostasis, cut off the tumor and extraperitonealized the stump. He finally cut off the extraperitonealized stump with the cautery five days after the intra-abdominal part of the procedure.

Pfannenstiel[5] excised a hemangioma of the liver and extraperitonealized the stump by sewing Glisson's capsule to the peritoneal wound. Beck,[6] finding an angioma as large as a man's head in the left lobe of the liver, placed rubber catheters about its pedicle as tourniquets and brought the mass out through the wound where it was allowed to slough away with frequent débridements. Israel[7] effected hemostasis in a case of angioma of the left lobe by placing a

* Harvey Cushing Fellow in Surgery.

From the Department of Surgery, Johns Hopkins Hospital and University.

1. Shumacker, H. B., Jr.: Hemangioma of the Liver, Surgery **11**:209, 1942.

2. Tinker, M. B.: Liver Resection, Ann. Surg. **102**: 728, 1935. Tinker, M. B., and Tinker, M. B., Jr.: Resection of Liver, J. A. M. A. **112**:2006 (May 20) 1939.

3. Turner, G. G.: A Case in Which an Adenoma Weighing 2 lb. 3 oz. Was Successfully Removed from the Liver, with Remarks on the Subject of Partial Hepatectomy, Proc. Roy. Soc. Med. (Sect. Surg.) **16**: 43, 1923.

4. Rosenthal, J.: Exstirpation einer Lebergeschwulst, Deutsche med. Wchnschr. **23**:54, 1897.

5. Pfannenstiel, P., cited by Langer, P.: Erfolgreiche Exstirpation eines grossen Haemangioms der Leber, Arch. f. klin. Chir. **64**:630, 1901.

6. Beck, C.: Surgery of the Liver, J. A. M. A. **38**: 1063 (April 26) 1902.

7. Israel, J.: Ein Fall von Exstirpation eines Lebercavernoms, Berl. klin. Wchnschr. **48**:662, 1911.

rubber tourniquet out through the wound. Two weeks later the tourniquet was cut and withdrawn safely.

The cautery was used by von Eiselsberg [8] in 1893 when he cauterized and packed the cut surface remaining after he had removed an angioma of the liver. Smoley [9] occluded the pedicle of an angioma in the left lobe with an elastic tourniquet, ligated it with mass ligatures, cut off the tumor with the cautery and sewed peritoneum over the stump.

Wright [10] excised from the right lobe of the liver a deeply embedded primary carcinoma the size of an orange. This nodule was removed by sharp dissection and shelling out with the finger. Large vessels were clamped and ligated, and the entire wound subsequently was packed. The packing was removed three days later.

Sutures and a clamp were employed as a means of hemostasis by Turner,[3] who operated on an adenoma of the right lobe of the liver so situated that it encroached on the bed of the gallbladder. The gallbladder was removed and the cystic duct drained. After placing a long, curved stomach clamp parallel to the proposed line of excision, the surgeon took alongside its blades a series of large, deep, interlocking sutures, using heavy catgut on a blunt, fully curved needle. These hemostatic sutures extended almost through the liver and were tied separately. The proposed segment of liver was then excised by cutting inside this line of sutures, and the bleeding from large vessels controlled by ligation with purse string sutures of catgut. The large, gaping wound in the liver was closed by approximating the upper surfaces, under surfaces and edge of the liver respectively. The sutures employed in accomplishing this closure were locked over the previously described hemostatic sutures, thus preventing their cutting out. Kidd [11] removed an adenoma the size of a cricket ball from the right lobe of the liver by an almost exactly similar technic.

Benson and Penberthy [12] encountered a pedunculated tumor in the anterior edge of the right lobe of the liver, which they excised with a v-shaped wedge of liver bearing the pedicle. They employed the cautery knife and placed omentum in the defect.

Shumacker [1] employed Kelly clamps, cautery and sutures in removing an angioma of the left lobe of the liver. The clamps were placed 1.5 cm. beyond the margin of the tumor and a small wedge of liver bearing the tumor was quickly excised by sharp dissection. The clamps cut through in the thick part of the liver, but manual pressure minimized hemorrhage. Through and through silk mattress sutures were placed within the line of clamp, and bleeding points subsequently seen when manual pressure was released were coagulated with the cautery. The bare surface of the liver was drained.

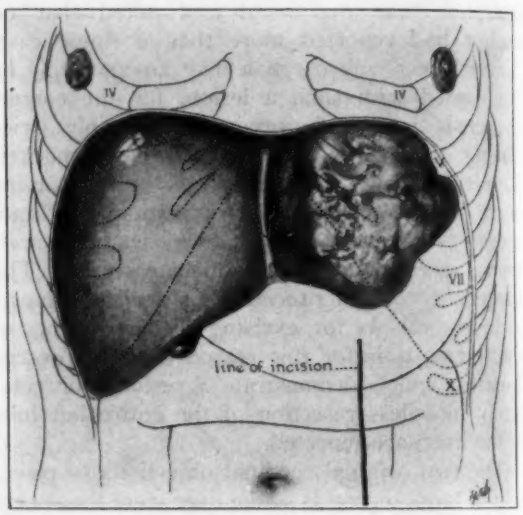


Fig. 1.—Topographic sketch showing position and extent of the primary carcinoma of the left lobe of the liver and the incision used to remove the lobe.

While the various ingenious procedures described are useful in resecting those lesions of the right lobe of the liver which do not include the extrahepatic biliary ducts, we have found that total extirpation of the left lobe is more easily and safely accomplished than excision of a part of it bearing a lesion. The reasons for this, as will be shown, are the thinness, relative avascularity and greater capacity for holding sutures which the insertion of the round ligament confers on the line of junction of the two lobes, together with the mobility of the lobe when it is freed from the falciform ligament. An additional advantage in the presence of an angioma or neoplasm is the wide avoidance of the tumor, a point repeatedly made by those [13] who have cut into such a vascular tumor.

8. von Eiselsberg, F.: Abtragung eines Cavernoms der Leber, Wien. klin. Wchnschr. **6**:1, 1893.

9. Smoley, K., cited by Pichler, K.: Ein Fall von Hemangioma Hepatis: Heilung durch Exstirpation, Ztschr. f. Heilk. **24**:250, 1903.

10. Wright, G.: Primary Carcinoma of the Liver Excised by Operation, Proc. Roy. Soc. Med. (Surg. Sect.) **16**:56, 1923.

11. Kidd, F.: Case of Primary Tumor of the Liver Removed by Operation, Proc. Roy. Soc. Med. (Surg. Sect.) **16**:61, 1923.

12. Benson, C. D., and Penberthy, G. C.: Surgical Excision of Primary Tumor of Liver (Hamartoma) in Infant Seven Months Old with Recovery, Surgery **12**: 881, 1942.

13. Horsley, J. S.: Cavernous Angioma of the Liver, Interstate M. J. **23**:347, 1916. von Eiselsberg.[8]

Total removal of the left lobe of the liver has been reported on two previous occasions. Keen [14] resected the entire left lobe as early as 1899. The lobe was the site of a carcinoma, and was removed by burning through the pedicle of the lobe with Paquelin's cautery. This procedure required twenty to thirty minutes; the large vessels were ligated as they were encountered. The edges of the wound in the liver were then partly approximated with catgut sutures, and the tended the left lobe so that it hung by a thin pedicle from the right lobe. In this case lobectomy was carried out simply by cutting the coronary ligaments, thus mobilizing the left lobe, and clamping and tying the pedicle.

Three times within the past four months and twice within one week, one of us (K. P.) has been confronted with three large lesions affecting the left lobe of the liver, for which removal of this lobe was carried out. This operation

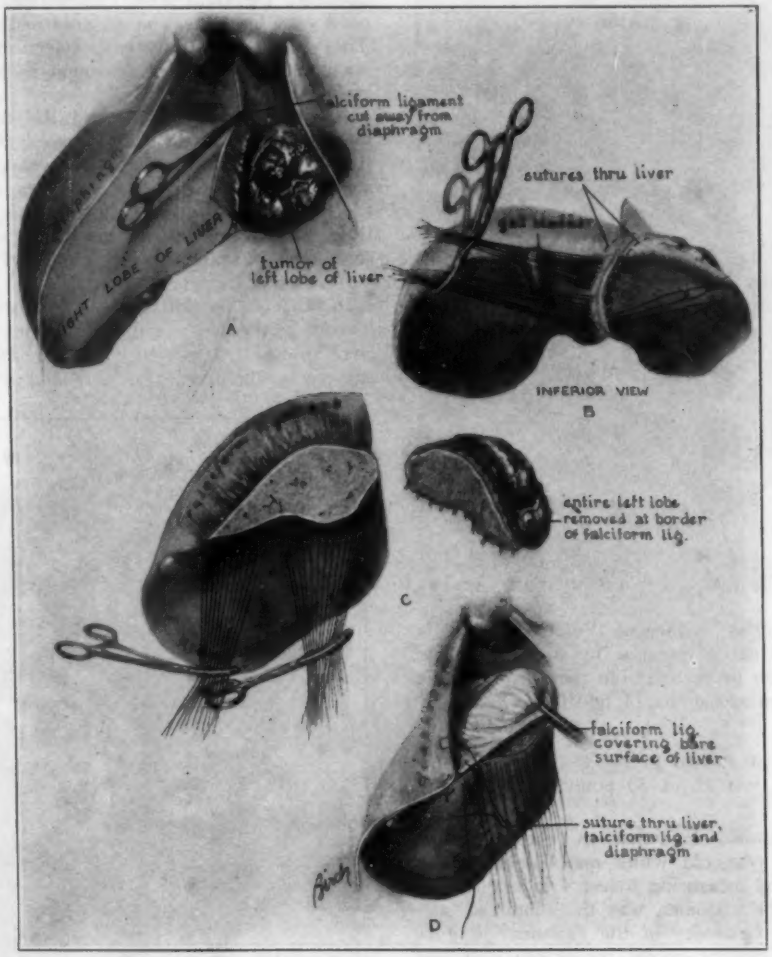

falciform ligament cut away from diaphragm
sutures thru liver
tumor of left lobe of liver
RIGHT LOBE OF LIVER
A
INFERIOR VIEW
B
entire left lobe removed at border of falciform lig.
C
falciform lig. covering bare surface of liver
suture thru liver, falciform lig. and diaphragm
D

Fig. 2.—Operative technic employed to remove the left lobe of the liver.

remaining open part was packed with iodoform gauze. A biliary fistula persisted for over ten days after the removal of the packing. The second case was that of Peck,[15] who found an angioma weighing almost 4 pounds (1.8 Kg.) in the left lobe of the liver. The tumor, apparently by its very weight, had stretched and ex-

was performed for carcinoma, hemangioma and gumma respectively. It should not be construed that we advocate excision of gummas of the liver; but it was the opinion of the operator (K. P.) as well as of numerous observers that we were dealing with a sarcoma, a tuberculoma or a carcinoma of the liver. An abstract of each case is presented.

14. Keen, W. W.: Report of a Case of Resection of the Liver for the Removal of a Neoplasm with a Table of Seventy-Six Cases of Resection of the Liver for Hepatic Tumors, Ann. Surg. **30**:267, 1899.

15. Peck, C. H.: Cavernous Haemangioma of Left Lobe of Liver, Surg., Gynec. & Obst. **33**:277, 1921.

REPORT OF CASES

CASE 1.—*Primary Carcinoma of Liver Treated by Removal of Left Lobe.*—A 64 year old white man, C. F. M., was admitted to the Johns Hopkins Hospital

on Aug. 6, 1943. He was a farmer who had enjoyed good health until about four months prior to admission, when he began to have dull, aching pain in the upper part of the abdomen which was associated with fulness, eructation and nausea. One month later, he noticed a mass in the left upper quadrant of the abdomen, which had increased progressively in size and had become extremely tender. When the patient was in the prone position the mass presented in the left upper quadrant,

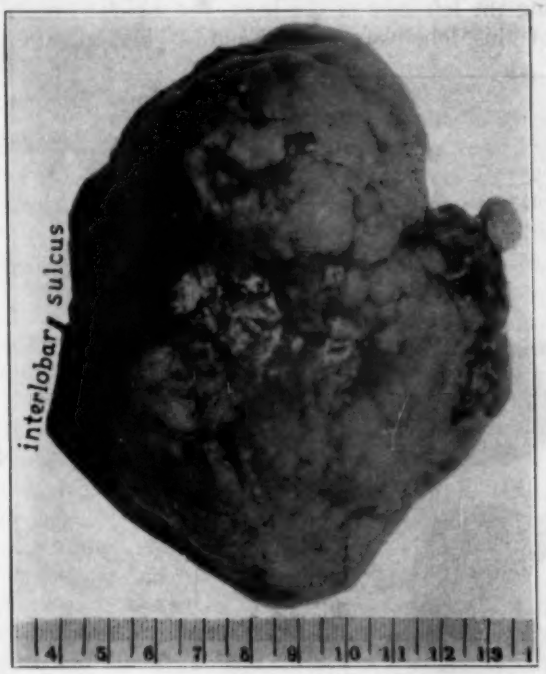


Fig. 3.—The anterior surface of the left lobe of the liver which was largely replaced by a large, white, nodular tumor which projected from the surface of the liver. The specimen measured 14 by 10 by 8 cm.

but when he stood it shifted to the lower part of the abdomen. He had lost about 35 pounds (16 Kg.) in weight.

Physical Examination.—Examination revealed a thin, well preserved 64 year old white man weighing 130 pounds (59 Kg.) and measuring 6 feet 4 inches (193.04 cm.) in height. The abdomen was the center of surgical interest; the remainder of the examination gave essentially negative results except for evidence of loss of weight and peripheral arteriosclerosis. In the prone position there was a mass beneath the left costal margin which measured about 4 inches (10 cm.) in diameter. It was well outlined, slightly tender and movable. When the patient was standing, the mass shifted to the lower part of the abdomen and could be moved to either side of the midline. The liver was not enlarged. Since the mass was so freely movable, no one suspected that it arose in the left lobe of the liver. The spleen could not be palpated. The rectum was normal.

Laboratory Data.—The serologic test for syphilis gave a negative reaction. The leukocyte count was 6,600; the hemoglobin was 14 Gm. The urine showed a trace of albumin. Roentgenograms of the chest showed the heart to be normal in size, and the lungs were clear. A gastrointestinal series and a barium enema disclosed no lesions. Gastric analysis made when the patient was fasting revealed no free acid, but thirty minutes after injection of histamine there was 38 degrees of free acid.

A preoperative diagnosis of a mesenteric cyst was made. Although the patient was seen by numerous observers, no one made a correct diagnosis.

Operation.—On Aug. 12, 1943, exploratory laparotomy was done with the patient under ether anesthesia; a left paramedian incision was made. There was no free fluid in the peritoneal cavity. Occupying the anterior-inferior part of the left lobe of the liver there was a bulging, nodular, friable, carcinomatous mass about the size of a clinched fist; there were no other nodules; the right lobe was normal. There were no peritoneal implants, and no enlarged mesenteric glands. The gallbladder, pancreas, spleen and kidneys were normal. No lesions were found in the gastrointestinal tract (fig. 1).

A frozen section confirmed the diagnosis of carcinoma, and it was decided to excise the left lobe of the liver. The falciform ligament was cut about one-half inch (1 cm.) from its diaphragmatic attachment (fig. 2*A*). This step allowed the left lobe of the liver to descend to the level of the incision. With sutures of braided silk threaded on Bloodgood needles, two rows of mattress sutures were placed parallel to each other in the interlobar sulcus, extending from the inferior to the superior or diaphragmatic surface. They were inserted so that they could be tied on the inferior surface of the liver (fig. 2*B* and *C*). These hemostatic sutures were then tied and the ends left long, after which the left lobe of the liver was removed by cutting through the liver substance between the parallel rows of sutures. This maneuver was performed in a bloodless field, and there was no soiling with bile. A

Fig. 4.—The posterior surface of the left lobe of the liver, which was largely replaced by a nodular tumor. By removing the left lobe, a relatively wide margin was obtained around the tumor. A braided silk suture is seen in the interlobar sulcus.

relatively wide margin of normal liver was removed with the tumor (fig. 2*C*).

The raw surface of the liver was then covered by bringing the free flap of falciform ligament down over it, and suturing it in this new position by using the long suture ends (fig. 2*C*). The left free edge of the right lobe of the liver was then fixed by suturing the falciform ligament to the diaphragm (fig. 2*D*). The incision was closed in layers with sutures of silk. Drainage was not employed. The operating time was thirty minutes.

Pathologic Report.—The specimen measured 14 by 10 by 8 cm. and consisted of the left lobe of the liver, which was largely replaced by a large, white, nodular tumor which projected from the liver surface (figs. 3 and 4). The remaining parts of the liver were normal. Histologic sections showed an undifferentiated glandular type of carcinoma, presumably arising from the biliary ducts. In some areas it was seen to enter the lymphatic vessels and veins (fig. 5).

Postoperative Course.—This was entirely uneventful. The highest temperature recorded was 100.8 F. on the second postoperative day. The incision healed by first intention, and the patient was discharged in one week. Tests for function of the liver showed no retention of bromsulfalein.

Since discharge the patient has been well except for attacks of constipation. He has gained 20 pounds (9.1 Kg.) and carries out the normal duties of a farmer (fig. 6). Another series of roentgenograms of the gastrointestinal tract, barium enema being given, and roentgenograms of the chest four months after the operation did not show any other lesion. Since the patient remains well, we have concluded that he had a primary carcinoma of the liver arising from the bile ducts.

CASE 2.—*Hemangioma of Liver Treated by Removal of Left Lobe.*—A 60 year old Negro man, A. McN., was admitted to the Johns Hopkins Hospital on Sept. 29, 1943. In 1929 a nodular goiter had been removed, and the patient was well until the onset of his present illness. About one year before admission the patient first became aware of a mass in the left upper quadrant of the abdomen. It had continued to increase in size until his present admission to the hospital. He had noted the presence of the mass in the upper part of the abdomen when lying down, but when in the erect position, he felt that it shifted to the lower part of the abdomen to either the right or the left of the midline. For several months he had been annoyed by a dragging feeling, which was accompanied by a sensation of fulness and some eructation. His appetite, however, had been normal and he had not lost weight.

Physical Examination.—The patient was a well preserved colored man of 62 years weighing 139 pounds (63 Kg.) and measuring 5 feet 7 inches (170.18 cm.) in height. There was no evidence of loss of weight. There was a well healed thyroidectomy scar. The heart and lungs were clear. The blood pressure was 160 systolic and 90 diastolic. The abdomen was slightly distended, soft and boggy. With the patient in the prone position one could see a round mass the size of a grapefruit in the left upper quadrant (fig. 7). The mass was firm and slightly tender and moved freely with respiration. It seemed to arise from the left lobe of the liver, which could not be separated from it. The right lobe of the liver could be palpated just beneath the costal margin. The mass pulsated with the aorta, but the pulsations were not expansile. The spleen could not be felt. When the patient was in the erect position the mass shifted to the lower part of the abdomen and could be moved to either side of the midline. It was when standing that the patient complained of a dragging sensation or a feeling of intra-abdominal heaviness. The remainder of the examination gave essentially negative results except for atrophy of the right testis.

Laboratory Findings.—The serologic tests were strongly positive for syphilis of the blood and spinal fluid. The hemoglobin was 12.5 Gm., the leukocyte count 5,000. Blood chemistry determinations were normal. Tests of the function of the liver showed only slight retention of bromsulfalein. A series of roentgenograms of the gastrointestinal tract showed that the stomach was displaced laterally and caudally by a large

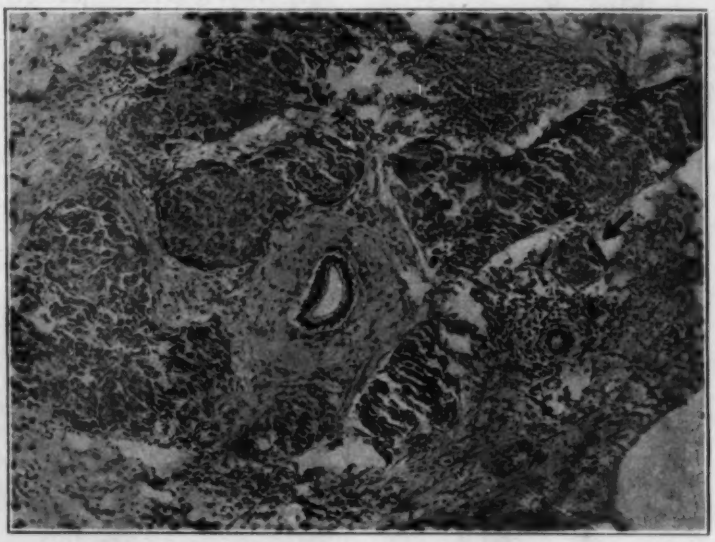


Fig. 5.—Low power photomicrograph showing an undifferentiated glandular type of carcinoma of the liver, presumably arising from the biliary ducts. As indicated by the arrow, in some areas the tumor entered the veins and lymphatic vessels.

mass, the center of which was calcified (fig. 8). There was no lesion within the stomach or duodenum.

Operation.—Operation was performed on Oct. 1, 1943. The patient was anesthetized with nitrous oxide, oxygen and ether. A left subcostal incision was made, which was extended to the right side. As soon as the peritoneal cavity was entered, one could see a giant hemangioma arising from the left lobe of the liver. The mass was about the size of a grapefruit (figs. 9 and 10). It was embedded in the left lobe of the liver and was surrounded by a narrow cuff or margin of normal-appearing liver. Inasmuch as there was no stalk from which it arose, in order to remove it one was forced to excise the left lobe of the liver, and the procedure was as follows:

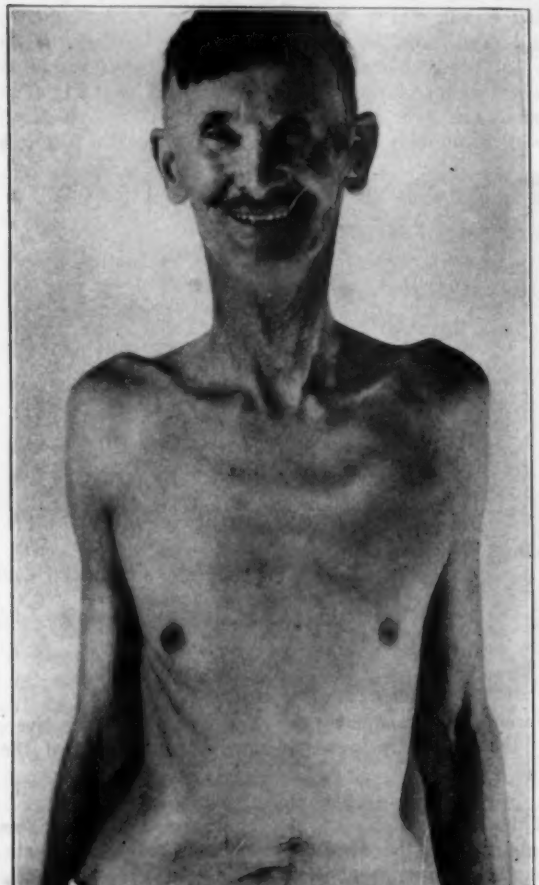


Fig. 6.—The patient four months after the removal of the left lobe of the liver for primary carcinoma of the bile ducts. The patient was discharged one week after operation. He has remained in excellent health and has gained more than 20 pounds.

The falciform ligament was cut about one-half inch from its diaphragmatic attachment (fig. 2 *A*). This procedure permitted mobility of the liver, so that the operator could work directly in the field. This exposure was further facilitated by extending the incision to the opposite side. With braided silk threaded on Bloodgood needles, a row of mattress sutures was inserted on each of the thinned-out, relatively avascular lines of union of the two lobes, as outlined in figure 2 *B* and *C*. With a scalpel the left lobe of the liver was removed by cutting between the two rows of sutures. There was no bleeding from the cut liver surfaces. The long suture ends from the right lobe were then rethreaded, and the falciform ligament, which

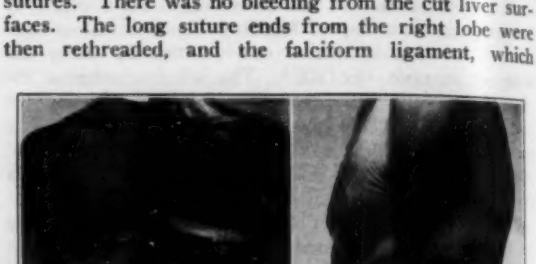


Fig. 7.—Preoperative photographs of patient with hemangioma of the left lobe of the liver (case 2) showing the bulging mass in the left upper part of the abdomen. The patient with the gumma (case 3) presented an almost identical appearance.

previously had been cut about one-half inch from its diaphragmatic attachment, was brought down over the raw surface of the liver and sutured into this new position, the long ends of the mattress sutures being used (fig. 2 *D*). The right lobe of the liver was then

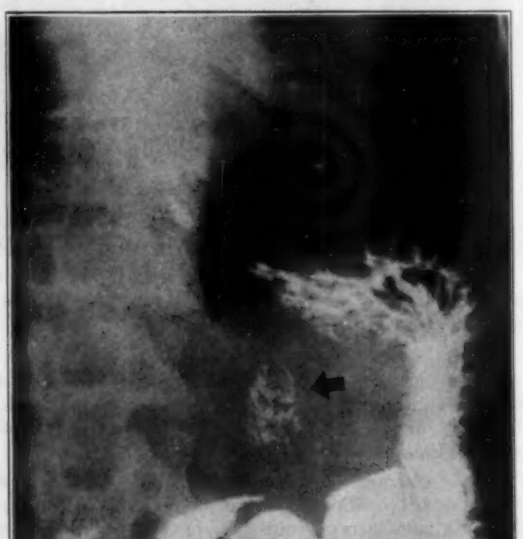


Fig. 8.—Roentgenogram showing lateral and caudal displacement of the stomach due to a large hemangioma of the left lobe of the liver. Circumscribed area of calcification in the hemangioma is indicated by the arrow.

anchored to the diaphragm by suturing the diaphragmatic attachment of the falciform ligament (which had previously been cut about one-half inch from the diaphragm) to its attachment in the liver. There was no soiling with bile or blood. Several grams of sulfanilamide was placed in the peritoneal cavity, and the abdominal incision was closed in layers with sutures of silk.

Pathologic Report.—The specimen consisted of the left lobe of the liver containing a large, soft hemangioma which measured 9 cm. in diameter (fig. 10). The hemangioma was surrounded by a cuff of liver measuring 2.5 cm., which appeared scarred and contained many large blood vessels. On section it was found to be well encapsulated, and filled with many large blood-filled spaces. The area of calcification which was seen in the roentgenogram (fig. 8) was located near the center of the hemangioma.

Histologic sections showed multiple dilated, blood-containing channels with epithelium, with very little stroma between the angiomatous channels. The cuff

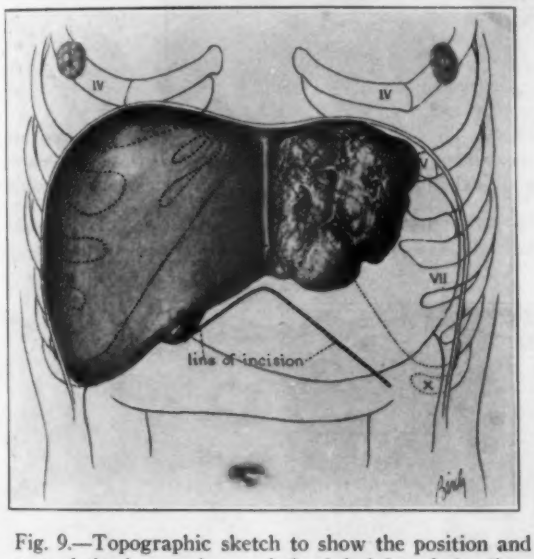


Fig. 9.—Topographic sketch to show the position and extent of the hemangioma of the left lobe of the liver and the incision used to remove the lobe.

of liver showed many large blood vessels leading to the hemangioma, and many bile ducts around the edge of the angioma (fig. 11).

Postoperative Course.—The patient's highest temperature recording was 101 F. on the second postoperative day. His convalescence was uneventful, the incision healed per primam (fig. 12, case 2), and he was ready for discharge two weeks after the operation. He returned to work one month after discharge from the hospital. He writes that he is receiving antisyphilitic therapy and is entirely well.

CASE 3.—*Gumma of Liver Simulating an Invading Carcinoma, Treated by Removal of Left Lobe.*—A 48 year old Negro man, W. S., was admitted to the Johns Hopkins Hospital on Sept. 29, 1943, because of abdominal pain.

About twenty-five years before admission the patient had a genital lesion which healed without specific therapy. He had received no antisyphilitic therapy. Three years before admission the patient had a coronary occlusion, for which he was hospitalized elsewhere. He occasionally complained of palpitation, dyspnea and precordial pain, which usually was initiated by overexertion.

The present illness began about three months prior to admission, when he began to have dull, aching pain in the upper part of his abdomen, interspersed with periods of sharp pain. He had noted progressive soreness of the abdominal wall, and about six weeks before admission felt a mass in the left upper quadrant of the abdomen. Although there were some fulness and eructation, there had been no nausea or vomiting. He had had tarry stools for a month or six weeks. He had lost about 25 pounds (11.3 Kg.) during the present illness.

He also complained of a painless swelling near the angle of the jaw on the right side, which appeared with the onset of his abdominal symptoms. On one occasion it had drained purulent material. It was his opinion that the mass had caused some diminution in hearing on the right side.

Physical Examination.—The patient was a chronically ill appearing-man of 48 years, weighing 128 pounds (58.1 Kg.) and measuring 5 feet 8 inches (172.72 cm.) in height. There was evidence of recent considerable loss of weight. The heart was enlarged 10 cm. to the left of the midsternal line in the sixth interspace. The rate was slow and regular. No murmurs were heard. The blood pressure was 120 systolic and 74 diastolic.

Of primary surgical interest was the abdomen, where there was a tremendous mass occupying most of the left upper quadrant (fig. 7). The mass was attached to the anterior abdominal wall. It was tender and indurated and moved only slightly with respiration. The right lobe of the liver could be palpated one finger-breadth beneath the costal margin, and the left lobe was continuous with the abdominal mass. The mass could not be moved, and there was no pulsation. There was a soft walnut-sized mass just beneath the angle of the jaw on the right side, surrounding which there were a few enlarged nodes.

Laboratory Data.—Reactions to the serologic tests of the blood for syphilis were positive. The hemoglobin was 13 Gm. and the leukocyte count 7,400. Roentgenograms of the gastrointestinal tract showed no intrinsic lesion of the stomach, duodenum or small intestine, and the stomach was displaced laterally and caudally. Another series showed no lesion in the large intestine. Intravenous pyelograms were normal. The stools did not contain blood.

A clinical diagnosis of retroperitoneal tumor with metastases to the cervical lymph nodes was made. The cervical mass was excised and histologic sections disclosed a tuberculous process. These microscopic changes complicated rather than simplified the picture. A diagnosis of gumma was not made by any one of either the medical or the surgical service.

Operation.—On Oct. 5, 1943, with the patient under nitrous oxide, oxygen and ether anesthesia a left rectus incision was made directly over the mass. The rectus muscle was invaded by the mass; therefore, we enlarged the incision both above and below, thereby entering the peritoneal cavity above and below the mass, which was still attached to the rectus muscle. The operative exposure was facilitated by excision of a large part of the anterior abdominal wall to which the tumor was attached. We could then see a tumor the size of a grapefruit arising in the left lobe of the liver (fig. 13). A thorough exploration of the abdomen disclosed no other abnormalities. The right lobe of the liver was slightly enlarged but it contained no nodules. There were no peritoneal implants. The retroperitoneal spaces were normal, as were the intra-abdominal organs. We thought that we were dealing with a sarcoma, a tuber-

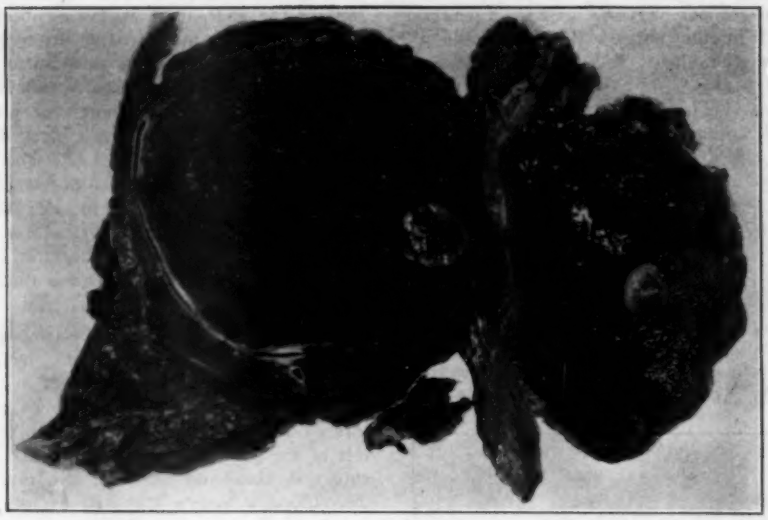


Fig. 10.—Photograph of hemangioma of liver for which the left lobe of the liver was removed. It measured 9 cm. in diameter and was surrounded by a cuff of liver measuring 2.5 cm. The hemangioma was well encapsulated and contained many blood-filled spaces. The area of calcification seen in the roentgenogram is readily discernible.

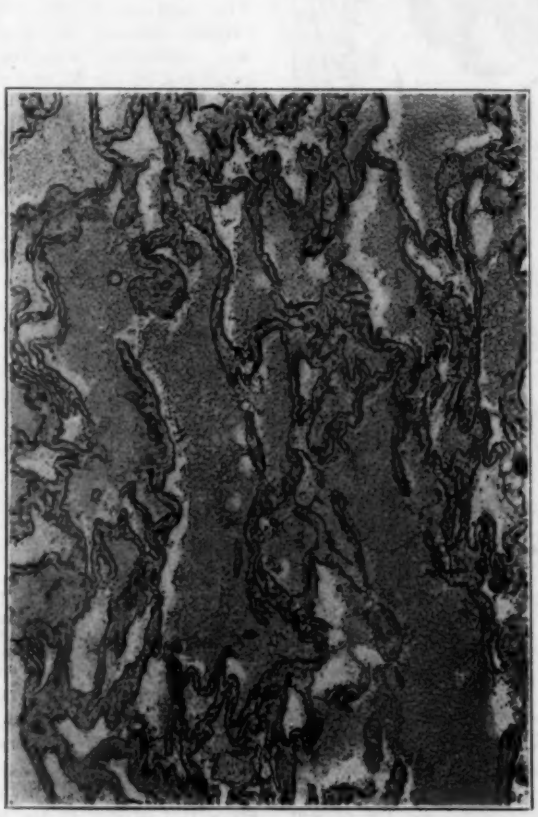


Fig. 11.—Histologic section of hemangioma of liver showing the multiple dilated blood-containing channels lined with epithelium. There was little stroma between the angiomatous channels.

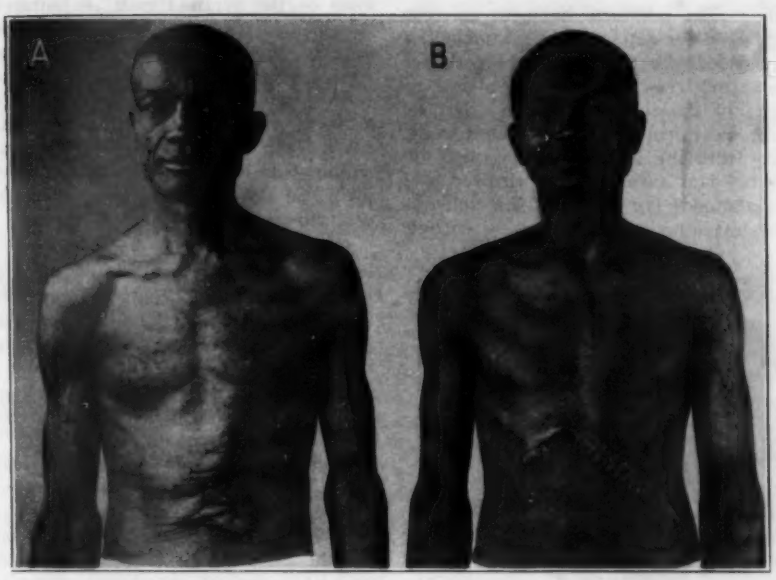


Fig. 12.—Postoperative photographs of patients taken two weeks after removal of the left lobe of the liver. A subcostal incision was used in case 2 (*B*)—hemangioma; a left rectus incision, with partial excision of the abdominal wall, was used in case 3 (*A*)—gumma of liver invading the abdominal wall.

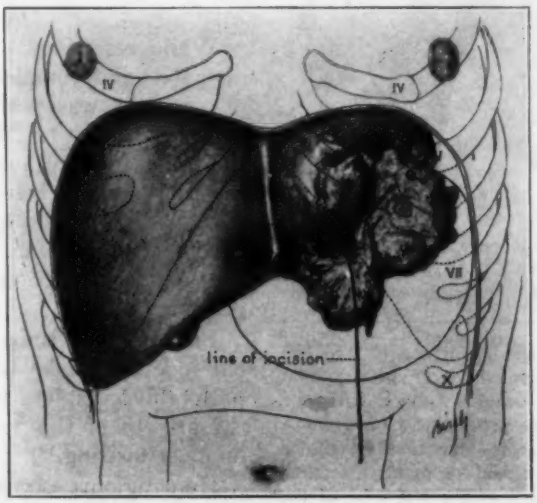


Fig. 13.—Topographic sketch to show the position and extent of a gumma of the left lobe of the liver and the incision used to remove the lobe.

culoma or a primary carcinoma. A frozen histologic section showed only avascular necrotic tissue. Excision of the left lobe of the liver was decided on. No one suspected that the tumor was a gumma.

Operative Technic: The falciform ligament was cut about one-half inch from its diaphragmatic attachment (fig. 2 *A*). With braided silk threaded on Bloodgood needles, two rows of mattress sutures were placed in the interlobar sulcus of the liver, just to the left of the insertion of the falciform ligament. These rows of sutures extended from the inferior to the superior surface of the liver. The sutures were tied on the inferior surface and the ends left long (fig. 2 *B* and *C*). With a scalpel the left lobe was removed by cutting between the two rows of hemostatic sutures. The free cuff of the falciform ligament was then brought down over the raw surface of the liver and sutured to the posterior aspect of the interlobar sulcus, the long free ends of the original mattress sutures being used. In this manner the raw surface of the liver was completely covered (fig. 2 *D*). The right lobe was then anchored by suturing the diaphragmatic attachment of the falciform ligament to the falciform reflexion on the cut surface of the liver (fig. 2 *D*). This procedure was carried out without loss of blood, and there was no soiling with bile. Several grams of sulfanilamide was placed in the peritoneal cavity, and the abdominal wall was closed in layers with sutures of silk.

Fig. 14.—*A* shows the anterior surface of the left lobe of the liver partially occupied by a white nodular mass which had invaded the anterior abdominal wall. Histologic section disclosed the process to be a gumma. The fissures in the specimen were due to the removal of blocks of tissue for frozen and permanent section. *B* shows the posterior surface of the left lobe of the liver partially occupied by a gumma, which was composed of numerous nodules of different consistency. At the time of operation, the process was thought to be either a neoplasm or a tuberculoma. Frozen section showed areas of necrotic liver, scattered giant cells and many mononuclear cells which in some areas formed "hard tubercles" in which the cells were epithelioid in appearance.

Pathologic Report.—The specimen consisted of the left lobe of the liver, which measured 20 by 16 by 10 cm. and was partially occupied by a white nodular mass measuring 10 cm. in greatest dimension (fig. 14). On cutting into this mass, which was largely necrotic liver tissue, it was seen to be composed of numerous nodules of different consistency. Surrounding the major mass, although independent of it, were several smaller nodules ranging up to 1 cm. in size.

Histologic sections showed the major mass to be a large gummatous area. In the more central portions of the lesion there was a great deal of necrotic liver; other areas of necrosis were caseous in appearance. On the periphery of some of the necrotic areas, and in general around the periphery of the whole lesion, there were many mononuclear cells and scattered giant cells. The mononuclear cells in places formed circumscribed hard "tubercles" in which the cells were epithelioid in appearance. Stains for acid-fast bacilli and spirochetes were negative.

Postoperative Course.—The patient's convalescence was entirely uneventful. The highest temperature recorded was 99.8 F. on the second postoperative day. His incision healed by first intention, and he was discharged two weeks after operation. Tests with bromsulfalein of the function of the liver showed 8 per cent retention.

COMMENT

While resections of the liver are rather uncommon, and complete removal of the left lobe of the liver was performed in only 2 reported cases, one of us (K. P.) was called on to excise the left lobe of the liver on three occasions within the four months before this article was written and twice within a period of one week. The conditions for which the left lobe of the liver was removed were carcinoma, hemangioma and gumma.

Primary carcinoma of the liver arising in the left lobe should be treated by wide excision or preferably complete removal of that lobe, since the growth of this tumor is slow and it is late in metastasizing.[16]

Hemangioma occurs more commonly in the liver than in any other internal organ. Although

16. Sternberg, G.: Lehrbuch der allgemeinen Pathologie und der pathologische Anatomie, Berlin, F. C. W. Vogel, 1928, p. 499. MacCallum, G. W.: A Text Book of Pathology, ed. 6, Philadelphia, W. B. Saunders Company, 1937. Ewing, J.: Neoplastic Diseases, ed. 4, ibid., 1941.

it is usually small and asymptomatic, occasionally it grows to sufficient size to cause symptoms, due not only to its position in the liver but to pressure on other organs or blood vessels. Rupture of a hemangioma of the liver occurs fairly frequently,[17] carrying with it grave risk and resulting in many instances in death.[18]

It should not be inferred that we advocate surgical removal of gumma of the liver. In case 3 the patient might have been spared an operation if the correct diagnosis had been made. However, no one, either clinician or surgeon, had suggested this diagnosis, and even at the time of operation we thought that we were dealing with a giant tuberculoma or a neoplasm. Frozen sections did not aid in the diagnosis, and the final diagnosis of gumma was not made by the pathologists for several weeks.

The liver has such great reserve functional capacity and regenerative ability that large areas may be destroyed by disease or removed surgically before hepatic function is clinically impaired. In none of our cases was there any evidence of impaired hepatic function either before operation or after the entire left lobe of the liver had been removed. In 1 case there was slight retention of bromsulfalein ten days after operation. Favorable for extensive excision of lesions of the right lobe of the liver and for complete removal of the left lobe when it is affected is the fact that regeneration occurs promptly and almost completely. Studies in resection and regeneration have been carried out by von Meister [19] and Fishback [20] on experimental animals in which as much as four fifths of the liver was removed, with almost complete regeneration in six to eight weeks.

Martens' [21] study of the blood supply of the liver has shown that the right hepatic artery anastomoses freely with the branches of the left hepatic artery, so that either lobe would probably receive an adequate blood supply if the artery of the opposite side was divided. Martens also showed that the left lobe and lobus quadratus are supplied by the left branch of the hepatic artery; that the right lobe is supplied entirely and the lobus caudatus mainly by the right hepatic artery, but that the lobus caudatus also receives a small branch from the left hepatic artery. This distribution of blood supply safeguards the remaining liver substance in case radical resection of either lobe is necessary, with sacrifice of the blood supply of that side.

SUMMARY AND CONCLUSIONS

Total extirpation of the left lobe of the liver has been reported twice. Partial excisions have been reported on numerous occasions. Removal of the entire left lobe of the liver is advocated, for it has been found to be more easily and safely accomplished than local excision of a large part of it containing a lesion.

Complete removal of the left lobe of the liver has been performed on 3 patients. Mobilization of the liver was obtained by dividing the falciform ligament near its diaphragmatic attachment. Hemostasis was accomplished by inserting two rows of mattress sutures of braided silk in the interlobar sulcus, which were tied on the inferior surface the ends being left long. The left lobe was then resected. The raw surface of the right lobe was covered with the falciform ligament. The right lobe was then firmly attached to the diaphragm the long suture ends being employed as figure-of-8 stitches.

Function of the liver after total extirpation of the left lobe has not been impaired.

17. Dahle, M.: Angioma hepatis med ruptur og blødning til bukhulen, Nord. med. (Med. rev., Bergen) **4**:3334, 1938. Karp, M.: Spontanruptur eines Leber Hämangioms, Zentralbl. f. Chir. **58**:1455, 1931. Marckstadt, K. O.: Ueber geplatze Hämangiome der Leber, Deutsche Ztschr. f. Chir. **250**:37, 1938. Pozzi, G.: Angioma cavernosa del Fegato, Clin. chir. **8**:625, 1932.

18. Hammer, F.: Beiträge zur Pathologie des Neugeboren, Ztschr. f. Geburtsch. u. Gynäk. **50**:213, 1903. Kissinger, C. C.; Sternfeld, E., and Zuker, S. D.: Rupture of a Cavernous Hemangioma as a Cause of Death in a Newborn Infant, Ohio State M. J. **36**:383, 1940. Leflaive, E.: Angiome du foie: Autopsie; examen microscopique, Bull. Soc. anat. de Paris **1**:379, 1887.

19. von Meister, E.: Recreation des Lebergewebes nach Abtragung ganzer Leberlappen, Beitr. z. path. Anat. u. z. allg. Path. **15**:1, 1894.

20. Fishback, F. C.: Morphologic Study of Regeneration of Liver After Partial Removal, Arch. Path. **7**:955 (June) 1929; Regeneration of Liver, Proc. Staff Meet., Mayo Clin. **3**:363, 1928.

21. Martens, E.: Röntgenologische Studien zur arteriellen Gefässversorgung in der Leber, Arch. f. klin. Chir. **114**:1001, 1920.

FRACTURES OF THE CARPAL SCAPHOID BONE IN INDUSTRY AND IN THE MILITARY SERVICE

LIEUTENANT COMMANDER M. G. HENRY (MC), U.S.N.R.

In a large industrial organization injuries to the wrist outnumber other injuries by a wide margin. These injuries include sprains that heal by themselves, sprains that become chronic and so-called "sprain fractures." Aside from these there is also the all too common "special case" which becomes progressively worse regardless of treatment. Carefully taken roentgenograms usually reveal a scaphoid bone with an ununited fracture. This type of injury presents varied problems. It is not alone a painful handicap to the patient and a perplexing case to the physician, but it is a decidedly trying case for the Accident Commission and becomes a serious economic liability in the yearly budget. In the military service the patient with a fractured scaphoid becomes a "complainer" and is not only a handicap to the service but, more important, exceedingly bad for the morale of the men in camp.

REVIEW OF LITERATURE

All writers on fractures of the scaphoid bone agree that this is one of the most easily overlooked injuries and, therefore, one of the most neglected and most frequently incorrectly diagnosed and improperly treated.

In 1907 Thomas Dwight [1] called attention to the weak internal structure in the middle region of this bone, the density of the structure at each end, and the fact that the proximal end has more strength than the distal end. In some scaphoids there are evidences of incomplete union of two distinct elements. There may be numerous anomalies in the scaphoid, as in other bones, and these anomalies are easily revealed in roentgenograms. Since this paper was completed I have accidentally discovered an anomalous scaphoid which was not only fractured but found to be congenitally fused with the greater multangular bone. A brief report of a case of this interesting anomaly will be made in a later paper.

Davidson and Horowitz (1938) [2] stated the belief that total excision of the scaphoid is the operation of choice in badly comminuted fractures, and that early excision results in a painless and normally functioning wrist with little or no deformity. They recommend total, not partial, excision. Five of 8 cases of nonunion with pain and disability in which they performed total excision showed excellent results. Our studies have led my colleagues and me to agree with the conclusions of these authors as to the advisability of this procedure.

Brittain [3] (1938) emphasized the fact that fracture of the scaphoid is the most common injury to the carpal bones, and decidedly the most neglected. However, one cannot agree with this author's recommendation of removal of the entire proximal row of carpal bones as the operative treatment for ununited fractured scaphoids. Such a radical procedure must greatly interfere with the mechanics of the joint and weaken its function decidedly.

Phillip Wilson [4] described the relatively poor blood supply in carpal bones. He brought out the fact that fractures of these bones were generally intra-articular and that the fragments were bathed in synovial fluid.

Lack of all periosteal callus as an important factor in causing slower fusion of the fractured fragments was brought out by Robert Johnson [5] in 1927.

In cases of dislocation of the fractured scaphoid Kellogg Speed [6] in 1924 recommended early operative removal, stating that this procedure promised the greatest return of function.

Our observations agree with those of Obletz and Holstein,[7] who stated that there is a characteristic tendency of fractures of the scaphoid to result in nonunion, and that this becomes one of the most disabling and serious afflictions of the wrist. From their anatomic studies of the scaphoid bone they show the relationship between

1. Dwight, T.: A Clinical Atlas: Variations of the Bones of the Hands and Feet, Philadelphia, J. B. Lippincott Company, 1907, pp. 3 and 4.

2. Davidson, A. J., and Horowitz, M. T.: An Evaluation of Excision in the Treatment of Ununited Fractures of the Carpal Scaphoid Bone, Ann. Surg. **108**:291 (Aug.) 1938.

3. Brittain, H. A.: Fracture of the Carpal Scaphoid. Brit. M. J. **2**:671 (Sept. 24) 1938.

4. Wilson, P. D.: Experience in the Management of Fractures and Dislocations, Philadelphia, J. B. Lippincott Company, 1938, pp. 40 and 41.

5. Johnson, R. W., Jr.: A Study of the Healing Processes in Injuries to the Carpal Scaphoid, J. Bone & Joint Surg. **9**:482 (July) 1927.

6. Speed, K.: The Fate of the Fractured Carpal Navicular, Ann. Surg. **80**:532 (Oct.) 1924.

7. Obletz, B. E., and Holstein, B. M.: Non-Union of Fractures of the Carpal Navicular, J. Bone & Joint Surg. **20**:424 (April) 1938.

the relatively inadequate circulation and the high incidence of nonunion. There is a narrow ridge running obliquely around the dorsal surface in which are found the arterial foramens through which the vessels supply the bone with nourishment. Fracture through the middle portion could interrupt the blood supply to the fragments, thus leading to necrosis. The synovial fluid present, they stated, exerts no serious action. There is some disagreement on the latter point. Wilson believes that its presence retards healing of the bone.

Fig. 1.—A striking photograph to bring out the rigid rule in technic that the hand must be in sharp ulnar deviation when roentgenograms are taken of the wrist. On the right, the normal anteroposterior view shows no evidence of fracture. On the left, same case, with the hand in sharp ulnar deviation a typical well marked fracture of the middle third of the scaphoid is brought out.

Fig. 2.—Complete malunion of fractured middle third of scaphoid and markedly necrosed bone with absorption and nonunion. The picture shows the result of total excision of the scaphoid. A perfect functional result was obtained in this case.

Bone grafting is regarded by some as highly effective. B. S. Adams[8] instituted this procedure in 1928, obtaining perfect anatomic and functional results. The exact technic may vary, but the operation is always essentially the same. A piece of tibia trimmed to proper size bridges the fracture line. The scaphoid fragments are prepared either by grooving or by boring a hole in the bone, care being taken not to injure the articular surfaces. A graft is preferred to a bone peg because it stabilizes the fragments more effectively.

Writers on this subject are in agreement as to the advisability of operative measures in treating these fractures. There is some disagreement as to the best treatment but the consensus is that excision of the bone in cases of nonunion of fractures results in relief of symptoms and nearly normal function of the wrist.

There is almost unanimous agreement that final results in these injuries must be judged clinically and not by roentgenograms alone. A roentgenogram may show complete union of the bone, but clinically the wrist may still be painful and ankylosed and, viewed from an industrial angle, a definite handicap.

Fig. 3.—This picture shows typically what we believe is a critical fracture through the inner middle third of the scaphoid resulting in nonunion and necrosis of the bone, even though every form of conservative treatment was tried out. Total excision of the scaphoid bone resulted in satisfactory function.

AUTHOR'S CASES

In this report I submit 12 cases of fractured carpal scaphoid from a five year survey of work done in a large industrial plant. The histories of the cases are omitted. The work in the industry was hazardous, and yet in the military service my survey of only four months shows nearly twice as many cases. The large number of men from all over the country together with

8. Adams, B. S.: Fractures of Bones of Hand and Fingers, Minnesota Med. **12**:515 (Sept.) 1929.

the severe commando type of activity makes for the greater number of cases in the army.

Of the 12 cases in industry over a five year period, 9 patients recovered completely with exacting but conservative management. They regained full painless function of the injured wrist in an average time of twelve weeks. Three patients, or 25 per cent, required surgical intervention, 2 for nonunion following prolonged conservative treatment and 1 for marked displacement of the lateral fragment.

During a four month period, from April through July of 1943, at a large receiving and embarkation base I was able to find 22 cases of fractured scaphoid. Practically all of these patients gave the same history of falling on the hand during rigorous exercise maneuvers. The time elapsed between their injury and the day of examination ranged from one day to three years. The table brings out the evident chronicity of pain and malfunction in these cases over long periods. Seventy-three per cent of the patients suffered from fracture through the middle third of the bone, while 22 per cent had fractures of the outer third and only 5 per cent of the inner third. All of these patients had pain in the wrist,

Fig. 4.—Fracture of the middle third of the scaphoid bone. Roentgenograms of both wrists show that when there is an anomalous ridge in one wrist there is a definite fracture through the anomalous ridge in the other wrist.

Fig. 5.—This picture shows severe dislocation in the carpal bones, also a fractured radius with a severely fractured scaphoid. Owing to excessive and severe injuries in this wrist, it was thought that the scaphoid would have to be removed. Three months later, when more severe pathologic processes elsewhere in the body were treated, the scaphoid was noted to be entirely healed, showing that even though other bones of the wrist were involved, circulation to the scaphoid per se was intact and union occurred.

especially on hyperextension of the hand and all had weakness in gripping. There were 7 cases (32 per cent) of definite nonunion. In all of these the fractures were of the middle third of the bone and the patients had total loss in dorsiflexion and pain on gripping. The average age of the patients in this survey is 25 years. A table of the results of this survey of cases at a United States Navy destroyer base follows.

COMMENT ON CASES

A thorough analysis of our cases has convinced us that no one set of rules can ever be ideal for this industrial as well as military problem. Each fractured scaphoid must be treated as an individual problem if satisfactory results are to be obtained. We do not believe that immobilization of the part can ever warrant a prognosis of the end result. A study of the anatomy of the wrist strengthens this belief. Any surgeon who operates on the carpus knows only too well how closely knit are the integral structures that make up the wrist joint. Nowhere else in the body are there such strong, short, closely knit ligamentous structures as those which hold these two rows of bones together, because nature here dictates the greatest amount of function compatible with ample protection and strength. For all these reasons it seems futile to attempt individual immobilization of an integral small bone in such an already closely knit organization. Naturally, pain itself automatically becomes a most efficient splint.

It is felt that the end result does not depend on immobilization, rest or any other conservative treatment, but rather on the site of the injury and whether or not this injury has destroyed or impaired the already poor circulation to the scaphoid bone. It has been our policy to operate as early as possible after the diagnosis is made, if operation is to be done, because we feel that this gives the best ultimate functional result. Undoubtedly, if one delays it will not only be necessary to deal with a fractured scaphoid per se, but also with subsequent chronic changes: sclerosis, calcification of the soft tissues and arthritic changes. When operation is performed late a partial ankylosis results and thus, to a certain degree, a permanently painful wrist joint.

We believe fractured scaphoids are so often overlooked because sufficient importance is not given to the complaint of "sprained wrist." Every physician has heard a patient say, "I fell on my hand and got a kink in my wrist; just a sprain." When this simple sprain does not get well, since a proper diagnosis has not been made, roentgenograms are taken, with the resultant diagnosis of a fractured scaphoid. The bad feature of this type of case is that chronic changes have occurred in the bone, and no matter what treatment is used the outcome will be most unsatisfactory. In addition the most important,

Data in Twenty-Two Cases of Fracture of the Carpal Scaphoid Bone at a United States Reviewing Station Destroyer Base from April 1 to August 1, 1943

Etiology	Age	Time Elapsed Since Injury	Site of Fracture	Weakness in Gripping	Pain	Loss of Motion—Permanent Injury
Fell on hand	24	3 years injured again	Mid. ⅓	Yes	Yes	Loss in dorsiflexion: nonunion
Fell on hand	27	1 day	Mid. ⅓	Yes	Yes	Yes
Fell on hand	26	1 day	Outer ⅓	Yes	Yes	Slight
Fell on hand	29	1 month	Outer ⅓	Yes	Yes	Healing callus
Struck wrist	25	1 day	Mid. ⅓	Yes	Yes	Fracture not complete
Struck wrist	22	1 month	Mid. ⅓	Yes	Yes	Fracture not complete
Fell on hand	21	2 months	Mid. ⅓	Yes	Yes	Nonunion: yes
Fell on hand	22	1 day	Mid.-outer ⅓	Yes	Yes	Incomplete fracture
Fell on hand	19	4 days	Mid. ⅓	Yes	Yes	Loss in dorsiflexion
Fell on hand	26	6 weeks	Mid. ⅓	Yes	Yes	Callus union good: incomplete fracture
Fell on wrist	26	1 month	Mid. ⅓	Yes	Yes	Incomplete fracture
Fell on hand	20	7 months	Mid. ⅓	Yes	Yes	Nonunion with absorption: pain and swelling
Fell on wrist	18	2 months	Outer ⅓	Yes	Yes	Healing all right
Run over by roller skate	18	1 day	Outer ⅓	Yes	Yes	Incomplete fracture
Fell on hand	22	2½ months	Outer ⅓	Yes	Yes	Incomplete fracture
Fell on arm	21	1 day	Inner ⅓	Yes	Yes	Incomplete fracture
Fell on hand	33	7 months	Mid. ⅓	Yes	Yes	Nonunion
Fell on hand	35	3 years	Mid. ⅓	Yes	Yes	Nonunion with bone absorption and separation
Fell on wrist	19	3 months	Mid.-outer ⅓	Yes	Yes	Incomplete fracture: healed
Fell on hand	35	3 years	Mid. ⅓	Yes	Yes	Pain: nonunion
Fell on wrist	22	1 day	Mid. ⅓	Yes	Yes	Incomplete fracture
Fell on hand	20	1½ years	Mid. ⅓	Yes	Yes	Nonunion with bone absorption: crepitus: total loss in dorsiflexion

as well as the most commonly used, function of the hand—that of gripping—is especially painful and weakened for a long time after the injury. Many physicians as well as patients cannot understand why after a so-called simple injury to the wrist the hand cannot be dorsiflexed and cannot grip ordinary objects with the same strength as before.

Any dislocation of the scaphoid we believe should be treated by total excision of the bone, because of the fact that minute as well as vital vessels are destroyed and the resulting dead bone becomes a painful foreign body. We stress the fact that circulation plays the predominant role in determining the outcome. If the already poor circulation of the scaphoid is further impaired by injury, there occurs a slow, sterile necrosis. The dead bone is gradually absorbed and replaced by fibrous tissue. Many an unhealed fracture line through a scaphoid bone is called healed when it is filled with dense fibrous tissue producing a syndesmosis rather than a synostosis.

We feel that interposition of the soft parts in this type of fracture has nothing to do with nonunion. It is also possible that the fractured scaphoid may be part of a picture of another fracture involving the hand and wrist, as for example fracture of the scaphoid is often associated with a simple Colles fracture. It is important in reducing a Colles fracture not to leave the most important part of the wrist unattended, because this one small bone may cause the patient more trouble than the longer fracture. We should like to call attention to the anomalous scaphoid which often is suggestive of a fracture, and may be mistaken for a fracture in roentgenograms. This anomalous ridge occurs near the middle third of the bone. One roentgenogram may give it the appearance of a fracture but another one taken with the hand in sharp ulnar deviation will show the true condition.

Attention should be called to the technic of taking the roentgenograms. When it is suspected that the scaphoid bone is fractured there should be extreme ulnar deviation of the hand in the roentgenograms; this position will bring out the bone in its entirety. In an instance in which this technic was not employed a negative roentgen report justified us in allowing the patient to return to work in a reasonable time. He returned to us later with a painful malfunctioning wrist. A roentgenogram made with the hand in sharp ulnar deviation showed an old fracture of the middle third of the scaphoid bone with complete nonunion and necrosis. We were then compelled to do a total excision, following which a satisfactory functional result was attained.

Fig. 6.—This picture brings out the importance of checking both wrists for comparison, especially when there is an anomalous ridge of bone present which is suggestive of fracture; however, if, as this picture shows, such a ridge of bone is present similarly in both scaphoids, a negative diagnosis is established.

Figure 1—the anteroposterior view—showed a fractured radius but nothing more. At a later date a view with marked ulnar deviation showed in addition a fracture of the middle third of the scaphoid. We believe that in any puzzling injuries of the wrist, roentgenograms with the hand in this position should be made as a matter of routine.

CONCLUSIONS

This survey gives the comparative frequency of fractured scaphoid bones in industry and in a large military naval base. Fractures of the carpal scaphoid are the most frequently missed of all

injuries to the wrist and therefore are the most neglected. They constitute a most serious industrial as well as military problem.

All sprains of the wrist not showing progress within a week should be examined roentgenographically.

Fig. 7.—A two and a half year old fracture of the middle third of the scaphoid with nonunion and separation and loss of function. This picture was taken in a case at a United States Navy destroyer base.

When roentgenograms are taken the hand should be in extreme ulnar deviation at the wrist joint. This procedure throws the scaphoid into clear view. Many fractured scaphoids are missed because this technic is not followed.

Complete fracture through the middle to inner third of the scaphoid with any degree of displacement should always be treated by complete excision, after swelling of the wrist has subsided. Fractures of the middle to inner third affect the nutrient arteries, and since the circulation is already poor, any impairment of this circulation is detrimental to firm, bony union.

When the fracture of this bone is a mere line, and the fragments of bone are in good apposition, with no displacement and little, if any, comminution, the treatment is conservative, consisting of immobilization, diathermy, whirlpool baths and passive and active movement.

When the scaphoid bone is seriously comminuted, and especially when the comminution involves—as it usually does—the outer third, early surgical treatment is advised. All the affected part should be excised, the main bone structure being left unmolested.

Any dislocation of the scaphoid should be treated by total excision of the bone.

Pain and weakness on gripping, as well as local pain or dorsiflexion, indicate a lesion of the scaphoid.

Any crushing of the scaphoid should be treated by complete removal of the bone. Fracture of the scaphoid is a commonly misdiagnosed condition; many so-called sprained wrists or sprained fractures are actually fractures and too frequently there is nonunion, because of poor circulation in the bone.

Fig. 8.—Three year old fracture of the middle third of the scaphoid with absorption of bone. The patient suffered severe pain and loss of function. (Preisser's syndrome.) The picture is of a case at a United States Navy destroyer base.

In a five year industrial survey there was an incidence of 25 per cent of nonunion in fractured scaphoids while in a large military base with more cases to report the percentage was 32.

HEAT AND MUSTARD GAS BURNS

A COMPARISON

LIEUTENANT COLONEL AMOS R. KOONTZ
MEDICAL CORPS, UNITED STATES ARMY

The object of this series of experiments is to make a comparison of the pathologic picture of heat burns and that of mustard gas burns, with a view to determining whether the same methods of treatment are applicable to the two types of burns.

HISTORICAL AND THEORETIC ASPECTS

Since the introduction of mustard gas into modern warfare during the first World War there has been much speculation as to the exact nature of mustard gas burns. There has been a general feeling that mustard gas burns are more persistent than heat burns of the same degree of intensity and that the healing process is slower. Little evidence has been adduced to prove this point.

It is true that Warthin and Weller,[1] who published a rather extensive monograph on mustard gas poisoning in 1919, did produce some evidence to support the general view. The following direct quotation is a summary of their findings:

> It differs from a heat burn in the absence of thrombosis, in the greater degree of fluid exudation, in the greater moistness of the affected area and in the fact that necrosis as shown by the loss of nuclei requires hours, or even days, for its complete development. The coagulated, shrunken and cooked appearance of the tissues in heat burns is not apparent in the tissues of mustard gas burns.
>
> The slow healing is probably chiefly due to vessel injury and the relatively slight leucocytic demarcating infiltration. In this respect the lesion is strikingly like an X-ray burn of the skin.

In spite of this pathologic study, there has been a feeling among a number of clinical surgeons who had wide experience with mustard gas burns during the first World War that such burns do heal readily and rapidly if infection is kept out and that, all circumstances being considered, the condition is no more prolonged, and the healing is no more delayed, than with heat burns of the same degree of intensity.

The presence of thrombosis in the small blood vessels in heat burns and its absence in mustard gas burns have been stressed by Warthin and Weller[1] and have been regarded as of considerable pathologic importance. However, MacCallum[2] in his discussion of heat burns stated that "thrombosis of the minuter vessels has been described by several, but others have failed to demonstrate any such occlusion, and it can hardly play an important part." Adami[3] and Delafield, Prudden and Wood[4] spoke of the thrombosis of blood vessels in third degree heat burns but made no mention of it in first and second degree burns. It seems highly probable that the problem of thrombosis and the factors causing it are no different in burns from either heat or mustard than they are elsewhere. Sufficient injury of any sort—mechanical, thermal or chemical—to any blood vessel causes thrombosis. It is quite likely that thrombosis in the vessels of areas burned with either heat or mustard is dependent on the amount of injury produced by the agent concerned.

A new feature has been introduced into the comparative study of heat and of mustard gas burns by the report from England[5] that as late as twenty-one days after exposure there are signs of "death pyknosis" in the nuclei of invading fibroblasts. Therefore, the English investigators believe that mustard or "something" stays in the skin up to twenty-one days and continues to cause damage. Control burns with heat and with chemicals did not produce the later death and pyknotic changes noted with mustard burns.

Obviously, from the foregoing considerations, it is not certain that there is any essential difference in the nature of heat burns and of mustard gas burns. Whether or not such a dissimilarity exists and, if it does exist, what the nature of the difference is are not matters of

1. Warthin, A. S., and Weller, C. V.: The Medical Aspects of Mustard Gas Poisoning, St. Louis, C. V. Mosby Company, 1919, pp. 79 and 80.

2. MacCallum, W. G.: A Textbook of Pathology, ed. 5, Philadelphia, W. B. Saunders Company, 1934, p. 360.

3. Adami, J. G.: The Principles of Pathology, ed. 2, Philadelphia, Lea & Febiger, 1910, vol. 1, p. 290.

4. Delafield, F.; Prudden, T. M., and Wood, F. C.: A Textbook of Pathology, New York, William Wood & Company, 1921, p. 10.

5. Walton, D. C.: Personal communication to the author.

purely theoretic or speculative interest. If there is no difference between the two types of burns, then the methods of treating heat burns are equally applicable to mustard burns. If a dissimilarity does exist, it is highly probable that the treatment will have to be varied somewhat. The object of this work is to determine this point.

PLAN OF EXPERIMENTAL STUDIES

OUTLINE OF EXPERIMENTS

During the course of this investigation, the following four series of experiments were made:

1. A comparative study (gross and microscopic) of heat burns and of mustard burns on dogs' skin, in which both stock dogs and Mexican hairless dogs were used, the latter being employed because their skin blisters and thus more nearly approximates human skin.

2. Experiments with goats to determine the relative amount of capillary thrombosis in heat burns and in mustard burns.

3. Experiments with goats to determine the extent of the inflammatory area beyond the point of application in heat burns and in mustard burns.

4. Experiments with rabbits to determine the relative healing time of mustard burns and of heat burns.

GENERAL PROCEDURE

Cutaneous burns were produced, as nearly as possible of equal degrees of intensity, by heat and by mustard. The heat burns were caused by applying a water-heated metal cylinder 1 cm. in diameter to the skin for three minutes. The temperature used was 80 C. The mustard burns were produced by applying liquid mustard to the skin by the usual rod method, except that a glass rod 1 cm. in diameter was used. Two applications were made in each instance.

Since details of procedure applicable only to certain experiments will be of greater value in the actual consideration of those experiments, such details have been incorporated in the records of the experiments to which they pertain.

RESULTS OF EXPERIMENTS

I. COMPARATIVE STUDY OF HEAT BURNS AND MUSTARD BURNS ON DOGS' SKIN

In this series of experiments, 14 stock dogs and 4 Mexican hairless dogs were used.

Gross and General Observations.—Just after exposure, the heat-burned areas appeared red, with a slight swelling about the outer parts. On the Mexican hairless dogs, small blisters appeared in these areas. Scabs formed within twenty-four to forty-eight hours, and these were depressed and hard. The scabs usually came off in from sixteen days to three weeks, leaving healthy scars.

Mustard when first applied caused a blanching of the area. This persisted for three or four hours, and then the area started to swell. Small blisters appeared in about twenty-four hours on the Mexican hairless dogs. The areas became scabbed about the fifth or the sixth day. The scabs were not as hard and depressed as those on the heat burns, and generally the surrounding areas were more swollen. The scab remained in most cases from sixteen days to three weeks and when it was lifted off a healthy scar was found underneath. The healing time was approximately the same with both types of burns.

The periods of healing of the burns as shown by the microscope were slightly longer than those observed with the naked eye, because there was generally a small area in the center of each burn not entirely healed that was not apparent in a gross examination. Sections of burns were taken beyond the healing time in order to note any differences in healed scars.

Résumés of the microscopic observations made after different intervals on (1) stock dogs and (2) Mexican hairless dogs are given in the sections to follow. In order to avoid confusion, all data for the stock dogs are presented first. In the reports on burns of stock dogs, most of the descriptions (those not otherwise specified) of stages of the burns are composite descriptions of sections taken from burned areas of all the dogs studied. In some instances, however, a description of the burns of a specific dog is used, and in these cases the specific dog is indicated by its serial number. These specific cases are included in order to show that there are individual differences in the rate of change in the pathologic process and that because of these differences it does not always show the progressive picture that might be expected.

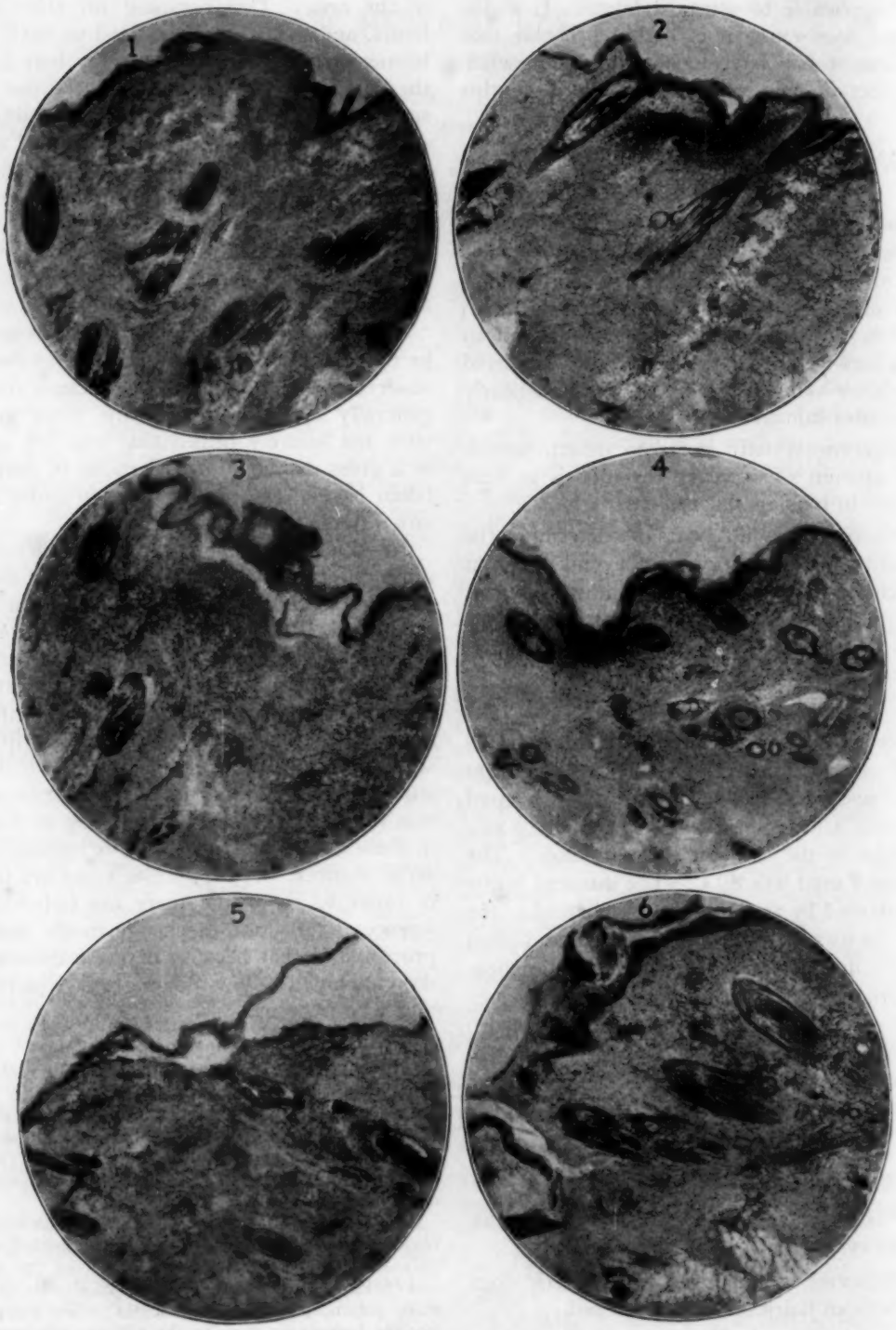
Microscopic Observations on Stock Dogs.

ONE HOUR.—Heat Burns (Fig. 1): The nuclei of the epithelium were pyknotic and there was fusion (coagulation ?) of the epithelial cells. The nuclei of the capillary endothelium were pyknotic, while those of the sebaceous glands were only slightly pyknotic. The horny layer was destroyed, and most of the blood vessels had collapsed.

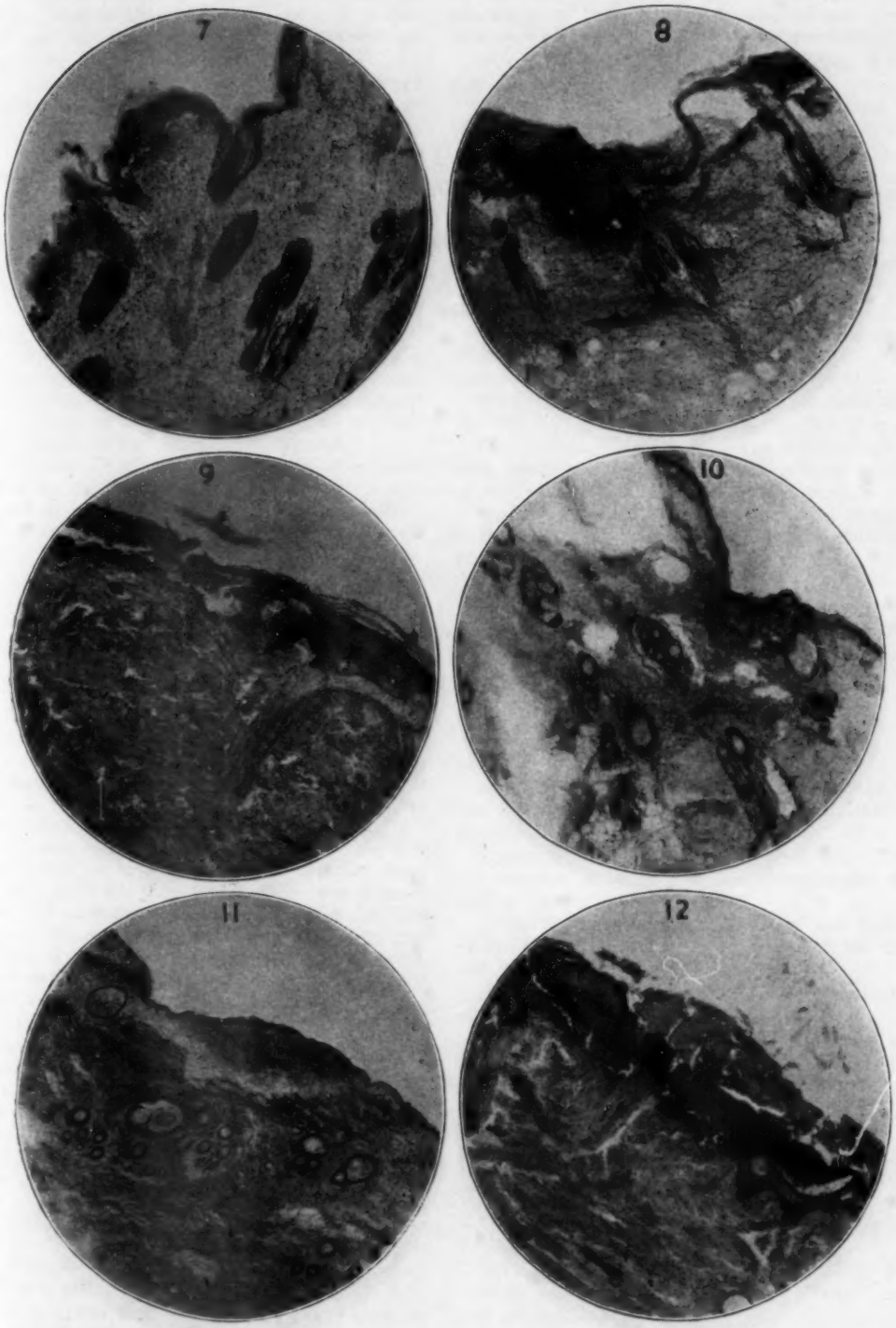
Mustard Burns (Fig. 2): The epithelium was rather normal in appearance; the nuclei of the epithelium were only slightly pyknotic, and the nuclei of the capillary endothelium were pyknotic. The capillaries contained many polymorphonuclear leukocytes; a few polymorphonuclear leukocytes were in the tissues, and most blood vessels had collapsed.

TWO HOURS.—Heat Burns (Fig. 3): The picture is the same as that of the one hour burns except for considerable leukocytic reaction.

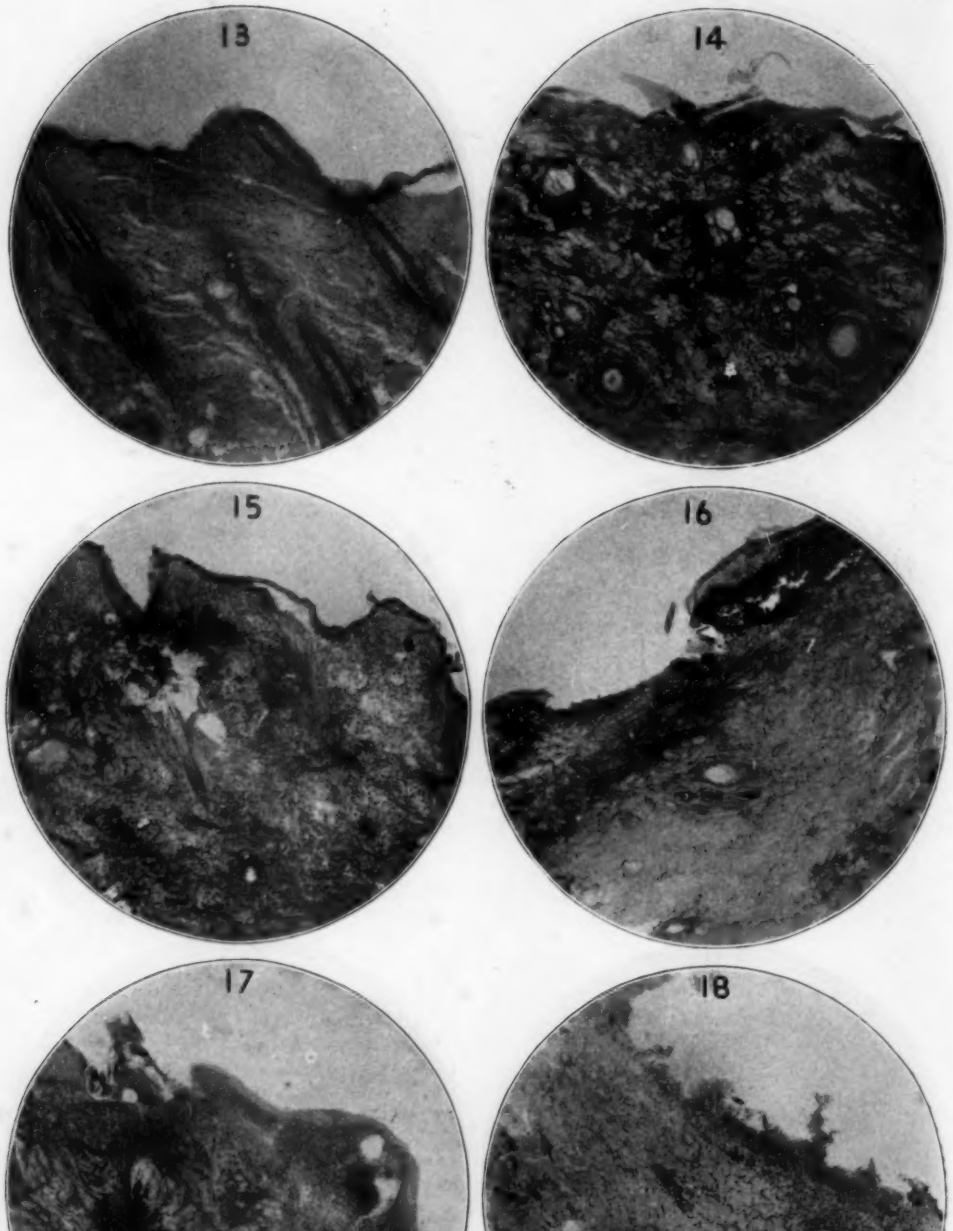
Mustard Burns (Fig. 4): The picture is the same as that of the one hour burns except for the presence of more polymorphonuclear leukocytes in the tissues.



Figs. 1 to 6.—Figure 1 shows a heat burn and figure 2 a mustard gas burn after one hour; figure 3 a heat burn and figure 4 a mustard gas burn after two hours; figure 5 a heat burn and figure 6 a mustard gas burn after three hours. (All sections were from stock dogs.)



Figs. 7 to 12.—Figure 7 shows a heat burn of a stock dog after twenty-four hours; figure 8 a mustard gas burn of a stock dog after twenty-four hours; figure 9 a mustard gas burn of Mexican hairless dog 15 after twenty-four hours; figure 10 a heat burn of a stock dog after forty hours; figure 11 a mustard gas burn of a stock dog after forty hours; figure 12 a heat burn of Mexican hairless dog 15 after forty-eight hours.



Figs. 13 to 18.—Figures 13 and 14 show heat burns after seventy-two hours; figures 15 and 16 mustard gas burns after seventy-two hours; figures 17 and 18 heat burns after ninety-six hours. (All sections were from stock dogs.)

THREE HOURS.—Heat Burns (Fig. 5): Fusion of the epithelial cells had occurred, with complete disintegration in some places, and the nuclei were extremely pyknotic. There were necrosis of the corium near the epidermis and considerable leukocytic reaction in this area. Pyknosis of the epithelium of the sebaceous glands was more noticeable than before.

Mustard Burns (Fig. 6): The epidermis showed more shrinkage in places and slightly more pyknosis of the nuclei, and there was an increase in leukocytic reaction.

TWENTY-FOUR HOURS.—Heat Burns (Fig. 7): Pyknosis of all the nuclei was more apparent but not as noticeable as in twenty-four hour mustard burns; the epithelium was broken down in one place with considerable inflammatory reaction. There was no evidence of thrombosis of the capillaries.

Mustard Burns (Fig. 8): Pyknosis was more noticeable; there were appreciable fusion of the epithelial cells and much shrinkage of the epithelium.

FORTY HOURS.—Heat Burns (Fig. 10): Coagulation and fusion of the epithelium were more pronounced; there was necrosis of the corium just next to the epidermis, with inflammatory reaction in this area.

Mustard Burns (Fig. 11): Pyknosis of the nuclei of the epidermis was intense in areas where coagulation had not taken place, and small points of inflammatory reaction were observed at scattered intervals under the epidermis.

FORTY-EIGHT HOURS.—Heat Burns: At this stage the picture was about the same as that of the forty-hour burns.

Mustard Burns: Coagulation of the epidermis was more advanced.

SEVENTY-TWO HOURS.—Heat Burns (Figs. 13 and 14): Complete necrosis of the epithelium and necrotic epithelium desquamated over large areas were observed, as well as considerable purulent reaction in the corium of the denuded areas, both at the surface and deeper in the corium. The nuclei of the capillary walls were intensely pyknotic.

Mustard Burns (Figs. 15 and 16): The picture was the same as that of the heat burns except that there was not quite so much pus, though there was a more widespread diffuse inflammation, extending deeper into the corium. The epithelium was necrotic and desquamated. The nuclei of the capillary walls were pyknotic, though not with the same degree of intensity as in the heat burns.

NINETY-SIX HOURS.—Heat Burns: (Figs. 17 and 18): The epithelium was entirely gone in some sections. The denuded corium presented the appearance of the wall of an abscess. There were surface hemorrhage, diffuse leukocytic reaction deep in the corium and pyknosis of the nuclei of all cells.

Mustard Burns (Fig. 19): The epithelium was still present in places but hardly recognizable as a cellular structure, coagulation and dissolution being so complete. Where the epitheluim was absent, the same picture was presented as in heat burns. Where the epithelium was present, even in a state of dissolution, it seemed to act somewhat as a barrier to infection.

FIVE DAYS.—Heat Burns: No change was observed from the condition of the ninety-six hour burns except that leukocytosis, both superficial and deep, was increased.

Mustard Burns: There was no change from the picture of the ninety-six hour burns, except that leukocytosis, both superficial and deep, was increased.

SIX DAYS.—Heat Burns (Fig. 20): The surface was covered with debris infiltrated with pus. All nuclei were moderately pyknotic. This stage was merely an extension of the fourth and fifth day processes.

Mustard Burns (Fig. 21): This phase was the same as that of the heat burns except that there was more infiltration of pus into the corium and was merely an extension of the fourth and fifth day processes.

SEVEN DAYS.—Heat Burns: The depth of the surface pus had increased.

Mustard Burns: This stage was the same as that of the six day burns.

EIGHT DAYS.—Heat Burns (Fig. 23): The surface was necrotic, and there were considerable round cell infiltration of the corium, some new fibroblasts and no pyknosis.

Mustard Burns (Fig. 24): The surface was covered with purulent debris, deeper and more extensive than before, and the nuclei of the corium were slightly pyknotic.

NINE DAYS.—Heat Burns: The surface was covered with fibrin and blood, with inflammatory infiltration, and the corium was infiltrated with round cells.

Mustard Burns: This phase was the same as that of the heat burns except that there was more pus.

TEN DAYS.—Heat Burns: The surface was covered with debris and fibrin, under which there was a layer of pus. There was no evidence of regeneration.

Mustard Burns: The picture was the same as that of the heat burns except that the pus had infiltrated to a greater extent.

ELEVEN DAYS.—Heat Burns (Fig. 25): A scab composed of fibrin, blood and pus overlying the ulcer and some regeneration and overgrowth of the epithelium were observed.

Mustard Burns (Fig. 26): This phase was the same as that of the heat burns, though there was less regeneration of the epithelium.

TWELVE DAYS.—Heat Burns: No change was observed.

Mustard Burns (Fig. 27): The only change observed was that more regeneration of the epithelium had occurred.

THIRTEEN DAYS.—Heat Burns (Fig. 30): There was regeneration of the young epithelium under the scab entirely across the ulcer.

Mustard Burns (Fig. 31): There was regeneration of the epithelium under the scab, though the ulcer was not bridged across.

FOURTEEN DAYS.—Heat Burns: No change was observed.

Mustard Burns: Further advances of the epithelial growth were noted.

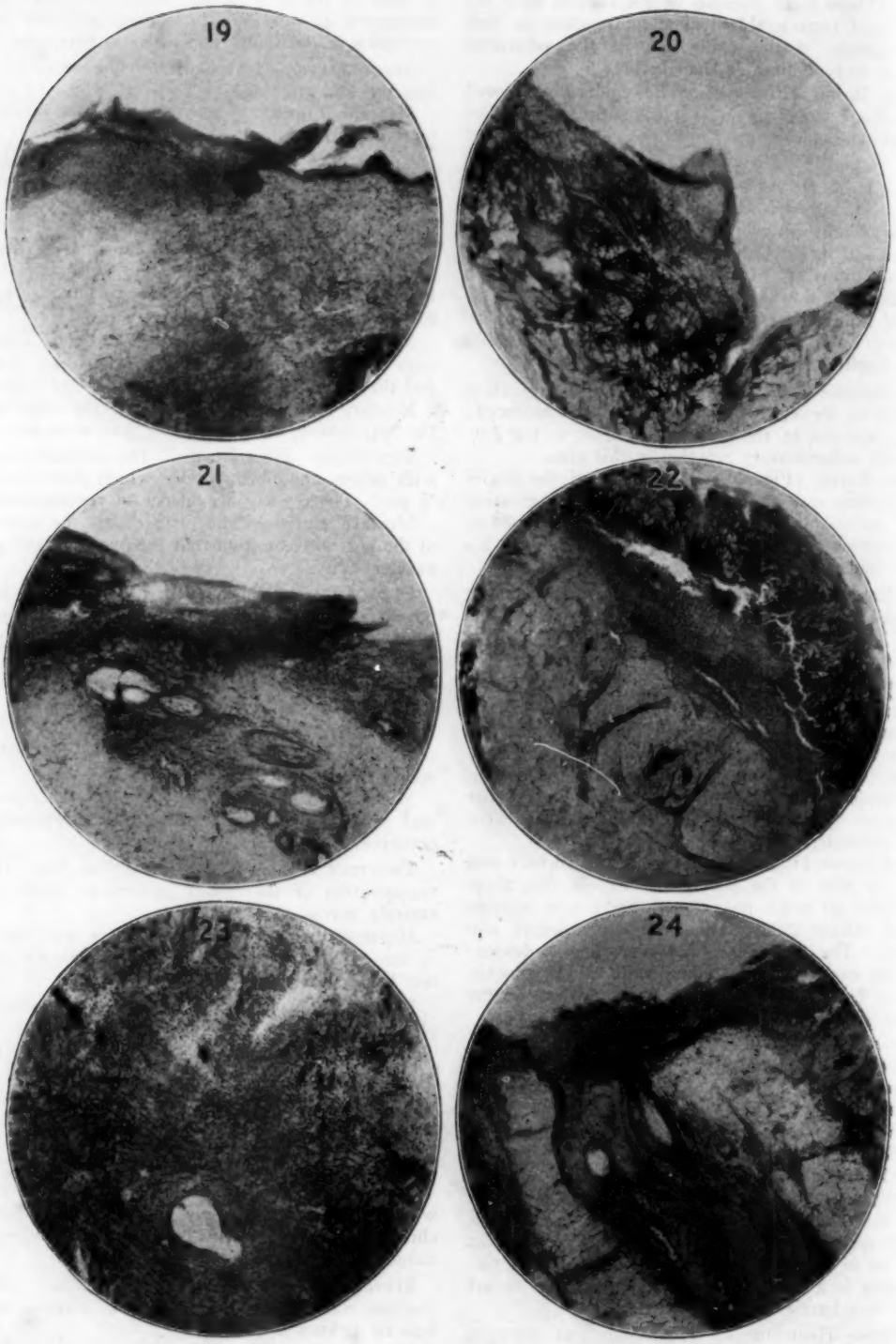
FIFTEEN DAYS (Dog 12).—Heat Burn: The surface was still covered with debris, which was lying on newly regenerated epithelium and granulation tissue covered with pus. There was no evidence of pyknosis.

Mustard Burn: The surface was covered with debris, which was lying on newly regenerated epithelium and chronic inflammatory tissue, resembling early granulation tissue. The nuclei were slightly pyknotic.

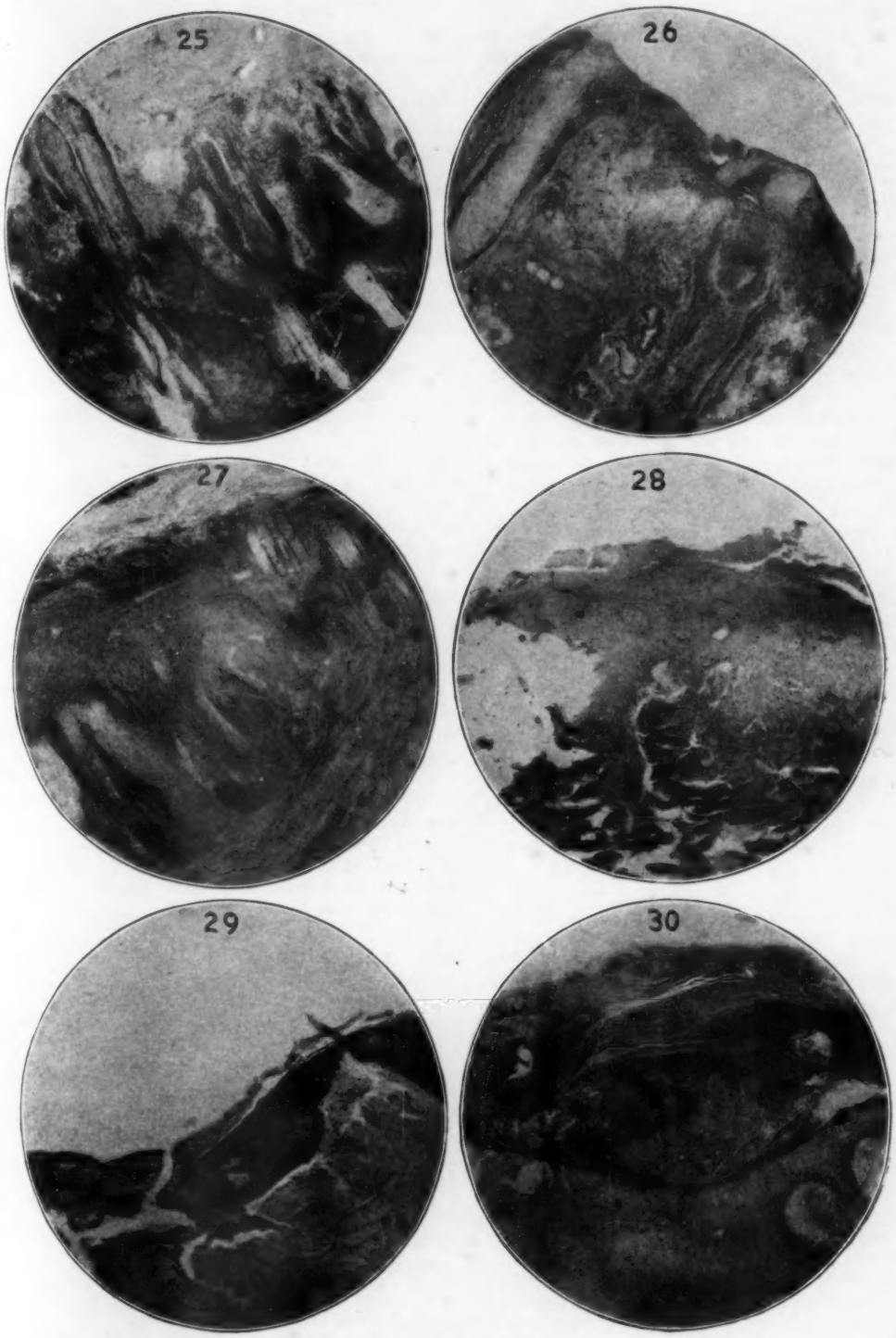
SIXTEEN DAYS.—Heat Burns (Fig. 32): New epithelium was lying on healthy new corium, and there was no pyknosis.

Mustard Burns (Fig. 33): This stage was the same as that of the heat burns except that there was but little new corium, and the new epithelium seemed to be lying for the most part on the old corium. (Had most of the inflammatory tissue sloughed off and the epithelium grown directly across the old corium?)

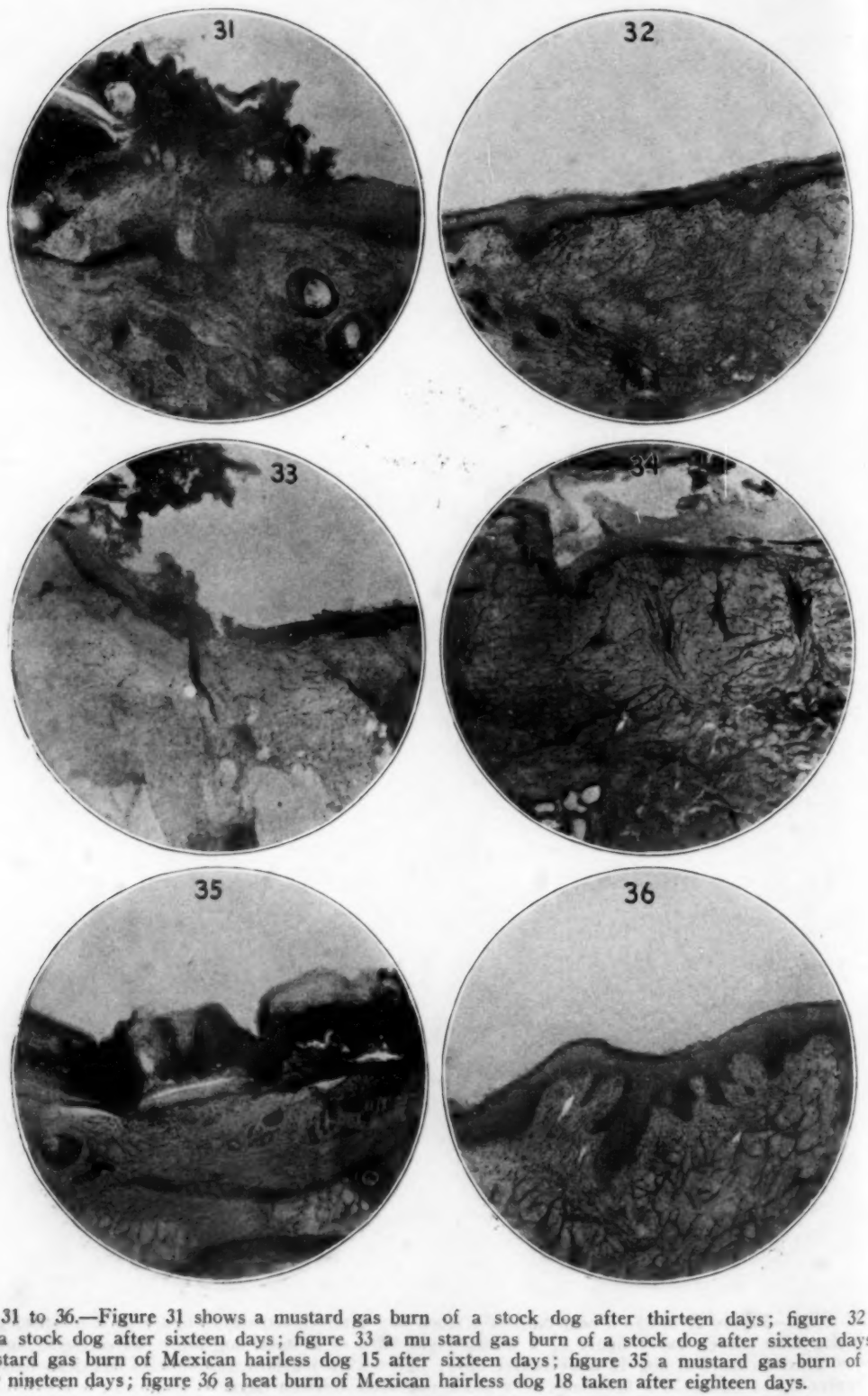
SEVENTEEN DAYS (Dog 13).—Heat Burn: No change was observed.



Figs. 19 to 24.—Figure 19 shows a mustard gas burn of a stock dog after ninety-six hours; figure 20 a heat burn of a stock dog after six days; figure 21 a mustard gas burn of a stock dog after six days; figure 22 a mustard gas burn of Mexican hairless dog 15 after six days; figure 23 a heat burn of a stock dog after eight days; figure 24 a mustard gas burn of a stock dog after eight days.



Figs. 25 to 30.—Figure 25 shows a heat burn of a stock dog after eleven days; figure 26 a mustard gas burn of a stock dog after eleven days; figure 27 a mustard gas burn of a stock dog after twelve days; figure 28 a heat burn of Mexican hairless dog 15 after twelve days; figure 29 a mustard gas burn of Mexican hairless dog 15 after twelve days; figure 30 a heat burn of a stock dog after thirteen days.



Figs. 31 to 36.—Figure 31 shows a mustard gas burn of a stock dog after thirteen days; figure 32 a heat burn of a stock dog after sixteen days; figure 33 a mu stard gas burn of a stock dog after sixteen days; figure 34 a mustard gas burn of Mexican hairless dog 15 after sixteen days; figure 35 a mustard gas burn of a stock dog after nineteen days; figure 36 a heat burn of Mexican hairless dog 18 taken after eighteen days.

Mustard Burn: There was partial regeneration of the epithelium. The base of the ulcer showed dilated capillaries and cellular debris. No inflammatory reaction or pyknosis of the nuclei was evident.

Eighteen Days.—Heat Burns: The only change noted was that the new corium looked slightly more mature.

Mustard Burns: This phase was the same as that on the sixteenth day.

Nineteen Days.—Heat Burns: No change was observed.

Mustard Burns (Fig. 35): New epithelium was noted under the scab, lying on new-looking corium similar to that observed on the slide of specimens taken from dogs sixteen days after occurrence of the heat burns.

Twenty Days (Dog 13).—Heat Burn: No change was noted, though the new corium now looked almost as mature as the old.

Mustard Burn: The ulcerated area was covered with cellular debris. There was no inflammatory reaction or pyknosis of the nuclei. Some regeneration of the epithelium was observed.

Twenty-One Days.—Heat Burns (Fig. 42): Regenerated epithelium (normal-looking, not thickened and not having prolongations) was lying on a thick layer of new corium.

Mustard Burns: Regenerated epithelium (thickened in places) was lying on a thin layer of new corium.

Twenty-Two Days.—Heat Burns: No change was noted.

Mustard Burns (Fig. 43): No change was observed, though there was one area the width of a low power field, where the ulcer was not bridged by epithelium.

Twenty-Three Days (Dog 14).—Heat Burn: The ulcerated area was covered with new epithelium, under which lay young connective tissue consisting of many new fibroblasts. There was no pyknosis.

Mustard Burn: This stage was the same as that of the heat burn except that the new epithelium and the connective tissue were not so compact and healthy looking. No pyknosis was observed. On another slide was observed (in the center) a typical chronic ulcer base, with leukocytes, round cells and new fibroblasts. No pyknosis was noted.

Twenty-Four Days (Dog 14).—Heat Burn: This was the same as that at twenty-three days. The epithelium was thicker than normal.

Mustard Burn: This stage was the same as that observed in a specimen taken from dog 14 twenty-three days after occurrence of the burn.

Twenty-Five Days (Dog 14).—Heat Burn (Fig. 46): This stage was the same as that observed twenty-three days after occurrence of the burn. Considerable proliferation of the epithelium at one point with chronic inflammatory tissue under it was observed.

Mustard Burn (Fig. 47): This stage was the same as that of the specimen taken from dog 14 twenty-three days after occurrence of the burn.

Thirty-Two Days (Dog 14).—Heat Burn: The slide was not satisfactory.

Mustard Burn (Fig. 52): New and thickened epithelium was lying on healthy young connective tissue. The regeneration was complete.

Microscopic Observations on Mexican Hairless Dogs.

One-Half Hour (Dog. 15).—Heat Burn: The picture was the same as that of one hour burns (ordinary dogs) except that the epithelium was almost completely destroyed and that the nuclei of the sebaceous glands were more pyknotic.

Mustard Burn: The cells of the horny layer were somewhat swollen, though there was otherwise no departure from the normal.

One Hour (Dog 15).—Heat Burn: This stage was the same as that observed one-half hour after occurrence of the burn.

Mustard Burn: This stage was the same as that observed one-half hour after occurrence of the burn.

Two Hours (Dog. 15).—Heat Burn: No change was observed.

Mustard Burn: No change was observed.

Three Hours (Dog 15).—Heat Burn: The picture was the same, except for slight leukocytic reaction, as that of the burn two hours after occurrence.

Mustard Burn: The epithelium was more swollen.

Four Hours (Dog 15).—Heat Burn: No change was observed.

Mustard Burn: No change was observed.

Twenty-Four Hours (Dog 15).—Heat Burn: There was appreciable inflammatory reaction, which was more evident than that in the stock dogs.

Mustard Burn (Fig. 9): The epithelium was losing its cellular character and was separating. There were inflammatory reaction and hemorrhage under it, which were more noticeable than those in the stock dogs.

Forty-Eight Hours (Dog 15).—Heat Burn (Fig. 12): Inflammatory reaction and hemorrhage were observed.

Mustard Burn: No change was noted.

Seventy-Two Hours (Dog 15).—Heat Burn: There was inflammatory reaction of the surface. The changes were not as pronounced as those in stock dogs.

Mustard Burn: The epithelium was breaking up, with pus under the necrotic pieces. Surface hemorrhage and leukocytic reaction extending deep in the corium were noted, which were more noticeable than those in the stock dogs.

Ninety-Six Hours (Dog 15).—Heat Burn: No change was observed.

Mustard Burn: No change was observed.

Six Days (Dog 15).—Heat Burn: There was superficial inflammatory reaction, and pyknosis of all the nuclei except those of sebaceous glands was observed.

Mustard Burn (Fig. 22): Superficial inflammatory reaction and surface hemorrhage were noted. The epithelium was entirely gone. There was pyknosis of all the nuclei except those of the sebaceous glands.

Seven Days (Dog 17).—Heat Burn: Superficial hemorrhage was observed.

Mustard Burn: Superficial hemorrhage and subacute inflammatory reaction (small round cells with pyknotic nuclei) were noted.

Ten Days (Dog 17).—Heat Burn: A thick layer of fibrin, under which there was a layer of pus, with inflammatory reaction in adjacent tissues, was present.

Mustard Burn: Exactly the same type of reaction as that in the heat burn was observed.

Twelve Days (Dog 15).—Heat Burn (Fig. 28): The wound showed no inflammatory reaction. There was regeneration of the epithelium at the edges.

Mustard Burn (Fig. 29): The wound showed little inflammatory reaction. Regeneration of the epithelium at the edges was noted.

Fourteen Days (Dog 17).—Heat Burn: The reactions were the same as those observed ten days after occurrence of the burn except that the pus was more attenuated.

Mustard Burn: The picture was the same as that of the heat burn, though the inflammatory reaction had subsided far more.

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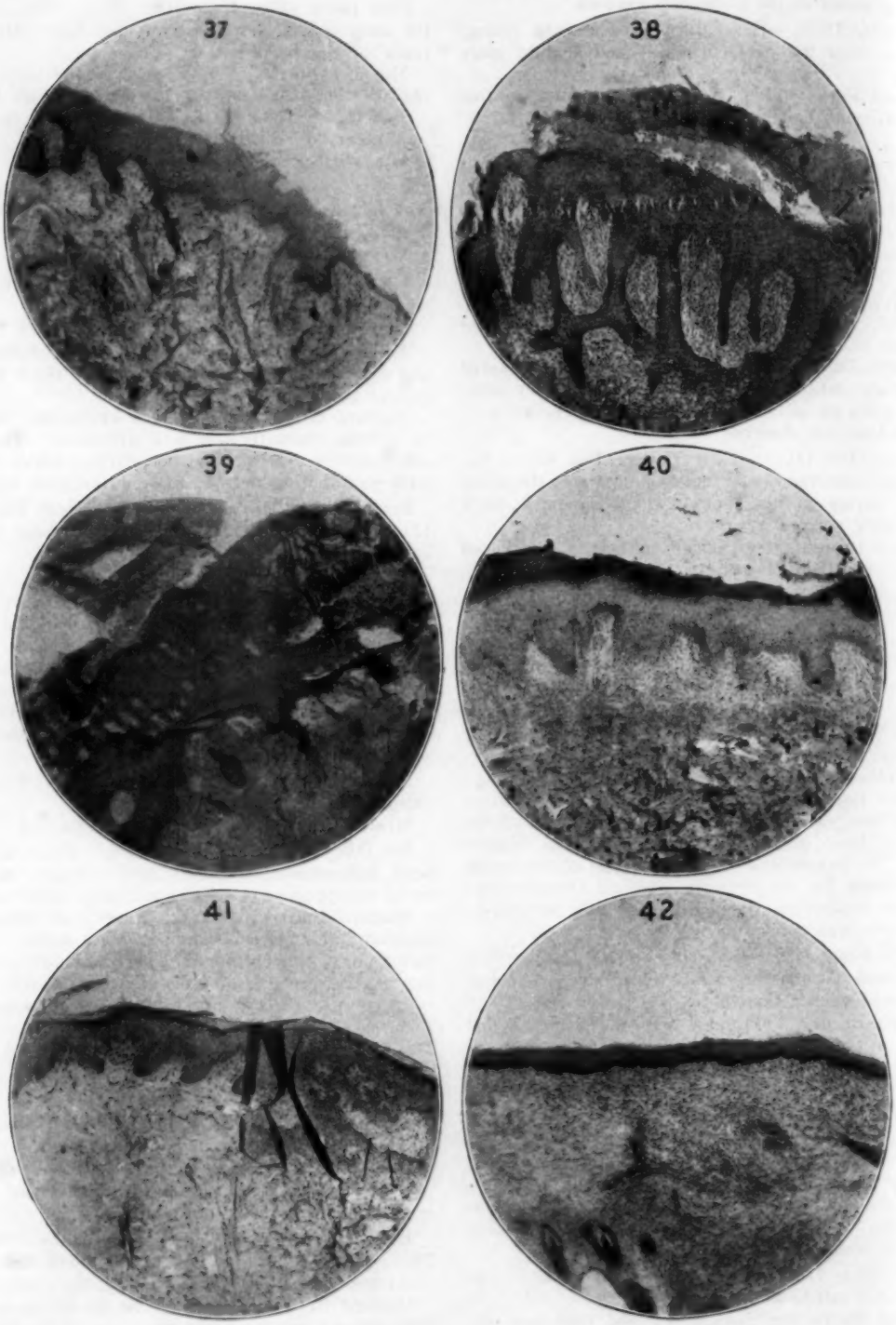
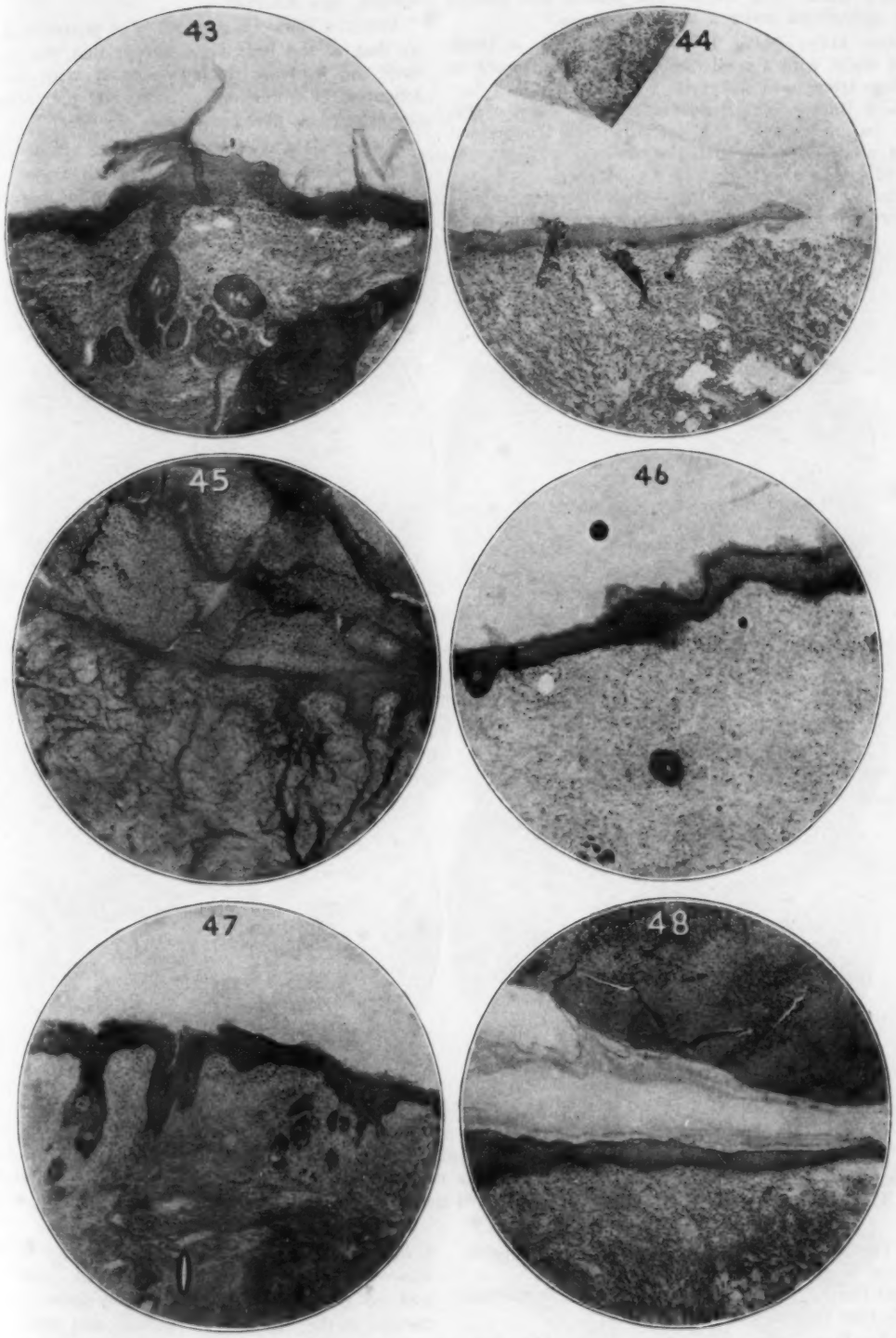


Figs. 37 to 42.—Figure 37 shows a mustard gas burn of Mexican hairless dog 18 after eighteen days; figure 38 a heat burn of Mexican hairless dog 18 after twenty days; figure 39 a mustard gas burn of Mexican hairless dog 18 after twenty days; figure 40 a heat burn of Mexican hairless dog 16 after twenty days; figure 41 a mustard gas burn of Mexican hairless dog 16 after twenty days; figure 42 a heat burn of a stock dog after twenty-one days.



Figs. 43 to 48.—Figure 43 shows a mustard gas burn of a stock dog after twenty-two days; figure 44 a heat burn of Mexican hairless dog 18 after twenty-three days; figure 45 a mustard gas burn of Mexican hairless dog 18 after twenty-three days; figure 46 a heat burn of stock dog 14 after twenty-five days; figure 47 a mustard gas burn of stock dog 14 after twenty-five days; figure 48 a heat burn of Mexican hairless dog 18 taken after twenty-five days.

Sixteen Days (Dog 15).—Heat Burn: No change was observed.

Mustard Burn (Fig. 34): The wound was almost entirely epithelized under a scab.

Sixteen Days (Dog 17).—Heat Burn: A thick layer of fibrin with a small amount of pus adherent to the under surface was observed.

Mustard Burn: There was regeneration of the epithelium in places. A mild superficial inflammatory reaction was noted where the epithelium was not regenerated. The ulcerated area was clean.

Eighteen Days (Dog 16).—Heat Burn: Inflammatory reaction extended deep into the corium in some places. There was regeneration of epithelium lying on new corium in other places.

Mustard Burn: Partial regeneration of the epithelium with little new corium was observed.

Eighteen Days (Dog 18).—Heat Burn (Fig. 36): New epithelium lying on new corium was of approximately the same maturity as that in other eighteen day burns. There was no pyknosis.

Mustard Burn (Fig. 37): The floor of the ulcer was clean except for slight inflammatory reaction. The scab was still present in some slides where the epithelium was regenerated to about the same degree as that in heat burns.

Twenty Days (Dog 16).—Heat Burn (Fig. 40): Regeneration of hypertrophied epithelium, lying on new corium, was observed.

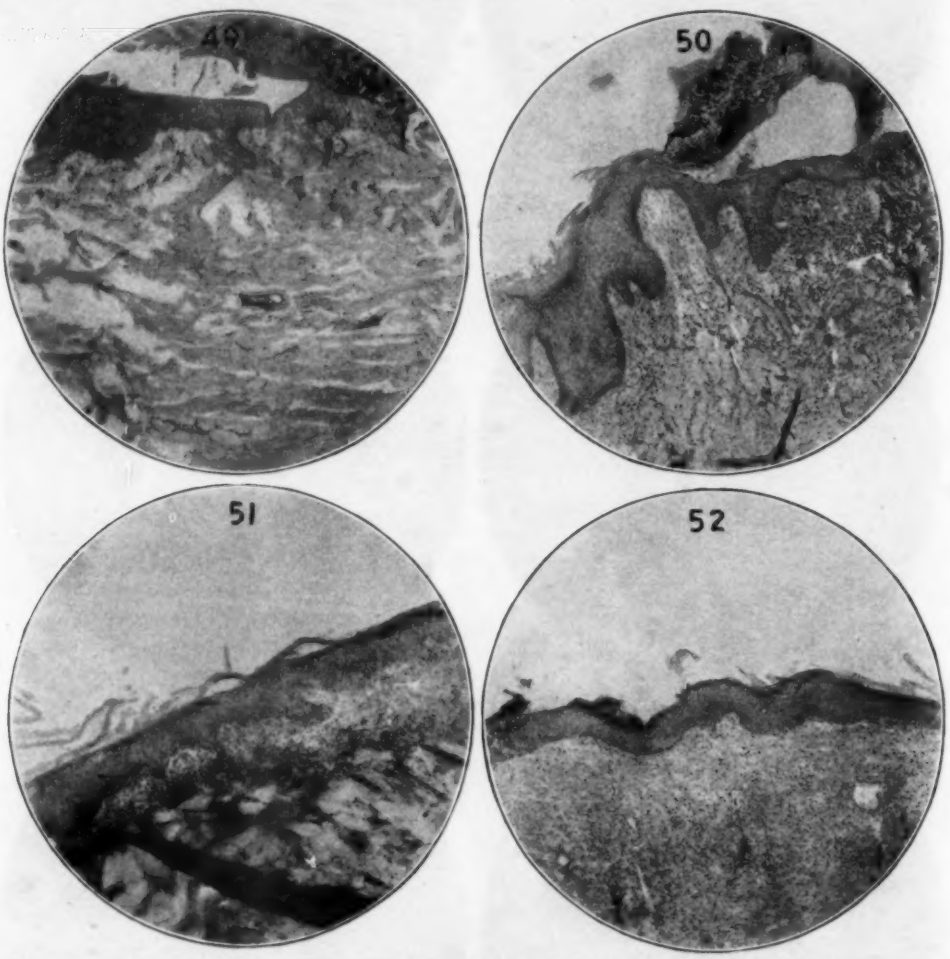
Mustard Burn (Fig. 41): The picture was the same as that of the heat burn except that the hypertrophy took the form of thickness rather than that of prolongation of epithelium growing into the corium. Also, there was less new corium.

Twenty Days (Dog 18).—Heat Burn (Fig. 38): The epithelium was completely regenerated under the scab and was greatly hypertrophied, being on a base of healthy-looking granulation tissue.

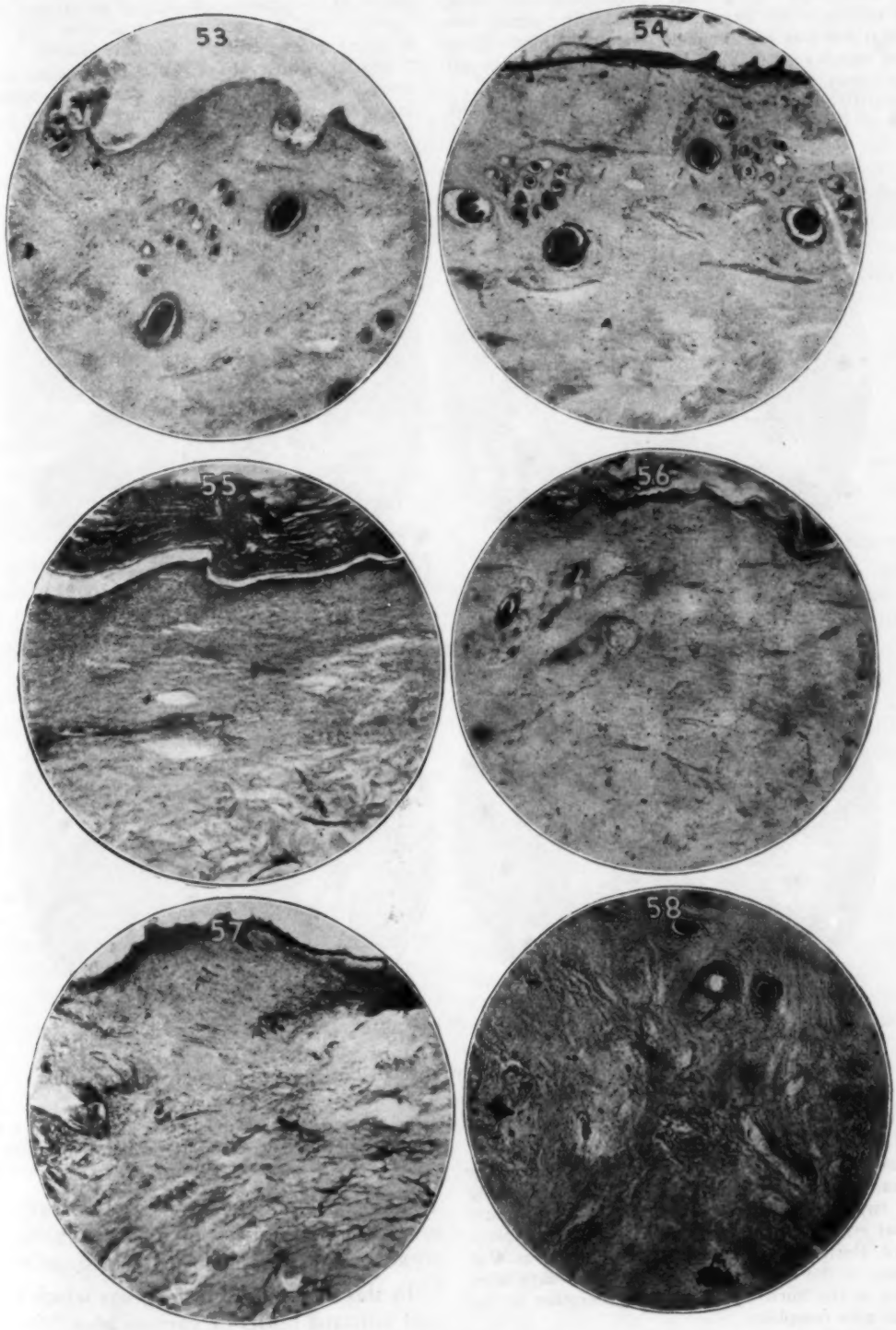
Mustard Burn (Fig. 39): The surface of the ulcer was covered with blood, fibrin and pus (scab). There was no granulation tissue. Regeneration of the epithelium at the edges under the scab was noted.

Twenty-Three Days (Dog 18).—Heat Burn (Fig. 44): There was regeneration of the epithelium except in the middle of the burned area. An overlay of scab composed of blood, fibrin and pus was observed.

Mustard Burn (Fig. 45): Regeneration of the hypertrophied epithelium on healthy granulations except in the middle of the burned area was noted. There was an overlay of scab composed of blood, pus and fibrin.



Figs. 49 to 52.—Figure 49 shows a mustard gas burn of Mexican hairless dog 18 after twenty-five days; figure 50 a heat burn of Mexican hairless dog 18 after thirty days; figure 51 a mustard gas burn of Mexican hairless dog 18 after thirty days; figure 52 a mustard gas burn of stock dog 14 after thirty-two days.



Figs. 53 to 58.—Sections of burned and of normal skin of goats injected with india ink.

Twenty-Four Days (Dog 18).—Heat Burn: No change was observed.

Mustard Burn: There was no change.

Twenty-Five Days (Dog 18).—Heat Burn (Fig. 48): There was regeneration of the epithelium except in the middle of the burned area. Healthy young connective tissue was present under the epithelium. There was an overlay of scab of blood, fibrin and pus. No pyknosis was observed.

Mustard Burn (Fig. 49): The picture was the same as that of the heat burn except that the layer of connective tissue under the new epithelium was much thinner. No pyknosis was noted.

Twenty-Six Days (Dog 16).—Heat Burn: The picture was the same as that of the heat burn of the dog observed twenty-five days after occurrence of the burn except that regeneration of the epithelium was complete.

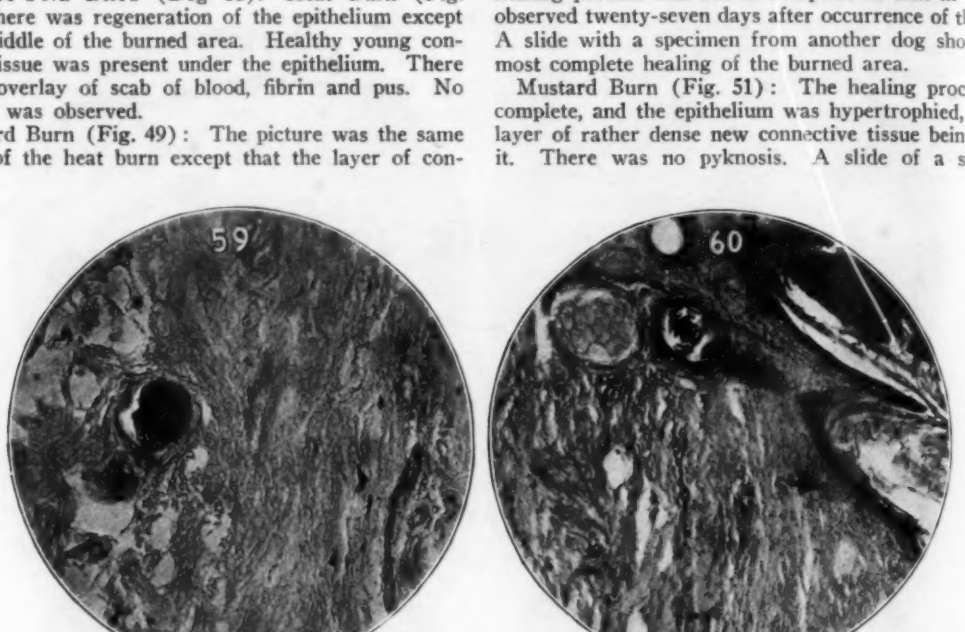
Mustard Burn: The picture was the same as that of the burn of the dog observed twenty-five days after occurrence of the burn except that regeneration of the epithelium was complete.

Twenty-Seven Days (Dog 18).—Heat Burn: The pathologic factors were the same as those of the burn of the dog observed twenty-five days after occurrence of the burn except that healing in the center of the burned area was more nearly complete. The new epithelium was hypertrophied.

Mustard Burn: The pathologic process was the same as that of the heat burn.

Thirty Days (Dog 18).—Heat Burn (Fig. 50): The healing process was not as complete as that in the dog observed twenty-seven days after occurrence of the burn. A slide with a specimen from another dog showed almost complete healing of the burned area.

Mustard Burn (Fig. 51): The healing process was complete, and the epithelium was hypertrophied, a thick layer of rather dense new connective tissue being under it. There was no pyknosis. A slide of a specimen from the burned area of another dog showed a gap not epithelized which was slightly wider than a low power field.



Figs. 59 to 62.—Sections of burned and of normal skin of goats injected with india ink.

II. EXPERIMENTS WITH GOATS TO DETERMINE THE RELATIVE AMOUNT OF CAPILLARY THROMBOSIS IN HEAT BURNS AND MUSTARD BURNS

In this series of tests 11 goats which had heat and mustard burns of various ages (the shorter periods, twenty-four and forty-eight hours, being used principally) were given injections of india ink in order to determine the relative amounts of thrombosis in the capillaries of the two burned areas. The india ink was injected into the

jugular vein, so as to get it into the general circulation and to make the possibilities of its reaching the various parts of the skin the same for all parts of the body. Specimens of the normal skin area were taken for microscopic examinations, as well as material from each of the burns on each goat. There was difficulty in some cases in getting the ink to enter the capillaries of the skin, possibly because of some mechanical property of the suspension. But when the ink did enter the capillaries, it entered those of the normal skin and those of the areas burned by heat and by mustard gas in about equal degrees, as is shown in figure 53 to 62. This seems to indicate that there was no thrombosis of the capillaries, because, if thrombosis were present, the ink could not have entered them.

III. EXPERIMENTS WITH GOATS TO DETERMINE THE EXTENT OF THE INFLAMMATORY AREA BEYOND THE POINT OF APPLICATION IN HEAT BURNS AND IN MUSTARD BURNS

Several goats with heat and mustard gas burns on their skins were given intravenous injections of trypan blue in order to determine the extent of the inflammatory reaction beyond the actual burned area. Menkin [6] had previously shown that trypan blue injected intravenously stained inflamed tissues deeply but passed through normal tissues, leaving them entirely unstained. In these experiments it was observed that the stained areas about the mustard burns were about twice the size of those about the heat burns, and this showed that the inflammatory reaction extended farther beyond the burned areas in the case of mustard gas burns than in the case of heat burns.

IV. EXPERIMENTS WITH RABBITS TO DETERMINE THE RELATIVE HEALING TIME OF MUSTARD BURNS AND OF HEAT BURNS

Heat and mustard burns, as nearly equal in intensity as possible, were made on the skins of rabbits, and they were photographed from time to time in order to show the progress in healing of the two types of burns. A number of rabbits were used, and little difference could be detected in healing time.

6. Menkin, V.: Studies on Deflammation: I. Fixation of Vital Dyes in Deflamed Areas, J. Exper. Med. **50**:171-180, 1929.

COMMENT

These experiments show minor, not pronounced and apparently not fundamental differences between heat burns and mustard burns. Warthin and Weller's observation as to the greater moistness of the affected area of mustard burns is correct. So far as I have been able to determine, the condition of the vessels in the two types of burns is the same. The leukocytic reaction in mustard burns is not so slight as Warthin and Weller's observations indicate. This reaction is more diffuse than the reaction in heat burns and extends farther into the corium. In heat burns, the reaction tends more toward a walling-off process, as in abscesses. Naturally, all burns in these series of experiments were infected—a condition which presented a uniformly complicating factor. Little difference could be made out in the pyknosis of the nuclei in the two types of burns.

From the practical point of view, the healing period is by far the most important period in either type of burn. There is little difference in the healing stages, either from the point of view of time or from the nature of the scars. The epithelium is hypertrophied in both instances. In the case of heat burns, the hypertrophy is apt to take the form of prolongations of epithelium into the corium, and in mustard burns, to take the form of fairly uniform thickening. Also, in the case of heat burns there seems to be more tendency to formation of granulation tissue, so that the new epithelium, when the wound heals, lies on a thicker layer of new corium than that on which the new epithelium lies in mustard burns.

Probably the most important result of this investigation is the demonstration of the fact that the healing time of heat burns and that of mustard burns of equal intensity are practically the same. (All of these burns were, of course, entirely untreated.) This seems to indicate that the same treatment is applicable to both types of burns.

CONCLUSIONS

So far as the experimental results herein reported are concerned, there is justification for drawing the conclusion that there is no major difference, either qualitative or quantitative between heat burns and mustard burns of equal intensity. The healing times of the two types of burns are practically the same.

UNTOWARD EFFECTS OF VARIOUS SUBSTANCES RECOMMENDED FOR BURNS OR WOUNDS

EXPERIMENTAL TESTS ON RATS

ROGER D. BAKER, M.D.
DURHAM, N. C.

Many substances have been recommended for application to burns [1] and wounds, either as dressings or detergents. Some of these have been subjected to testing in rats, and the results are herewith presented.

Testing of substances for local effect on human beings under controlled conditions may be satisfactory and harmless, as shown by Cannon and Cope,[2] who applied tannic acid and methylrosaniline chloride (gentian violet) to donor sites from which skin had been removed for grafting, and compared the rates of healing with those of a control area. Spontaneous human burns and wounds vary so greatly in size, depth, location and cleanliness that they cannot be used as standardized lesions to judge therapeutic results.

A method has been devised utilizing an inexpensive laboratory animal, the rat, which indicates the necrotizing effect locally in a quantitative fashion, and which permits some conclusions to be drawn regarding the general effects resulting from absorption of the material to be tested.

A previous report by Handler and me has been published [3] in which essentially this method was used in studies on tannic acid. From them it was learned, for instance, that hepatic necrosis could be produced by applying tannic acid in either ointment or aqueous form to the area denuded of skin, if the area was large enough. Extensive studies have been reported recently by Hartman and Romence,[4] who used dogs to test particularly damage to the liver resulting from various agents which have been used on burns.

Adult white rats are anesthetized with ether and the skin of the abdomen and thorax is removed over an area 8 by 10 cm. The material to be tested is then applied to this skinned area for a standard period of time (three minutes in the following experiments) by means of gentle swabbing with cotton pledgets. The rats are not bandaged. Their behavior after the application is observed. They are killed at the end of twenty-four and forty-eight hours, autopsy is performed, and the treated abdominal wall, heart, lungs, liver, spleen and kidneys are taken for histologic examination. The time intervals selected are those at which histologically demonstrable damage becomes manifest and before changes due to bacterial contamination are important. In addition the stage of healing or repair has not begun to any appreciable extent.

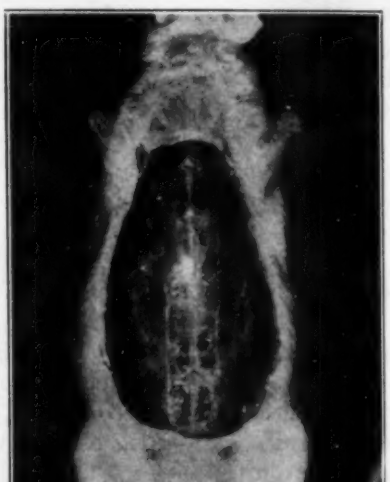


Fig. 1.—Size of area of skin removed from rats to make the tests reported in table 1. The muscle of the abdominal wall lies exposed, but a transparent layer of connective tissue overlies the muscle.

From the Department of Pathology, Duke University School of Medicine and Duke Hospital.

The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Duke University.

1. Harkins, H. N.: The Treatment of Burns, Springfield, Ill., Charles C Thomas, Publisher, 1942.

2. Cannon, B., and Cope, O.: Rate of Epithelial Regeneration: Clinical Method of Measurement, and Effect of Various Agents Recommended in Treatment of Burns, Ann. Surg. **117**:85-92 (Jan.) 1943.

3. Baker, R. D., and Handler, P.: Animal Experiments with Tannic Acid Suggested by the Tannic Acid Treatment of Burns, Ann. Surg. **118**:417-426 (Sept.) 1943.

4. Hartman, F. W., and Romence, H. L.: Liver Necrosis in Burns, Ann. Surg. **118**:402-416 (Sept.) 1943.

The method, as used, indicates the direct necrotizing effect of the substance applied and also the generalized acute effects as indicated by death of the rat, abnormal behavior of the rat or histologic changes in the more important viscera. If the effect of substances on rate of healing, or long time toxic effects, were to be studied the experimental procedures would need appropriate modification.

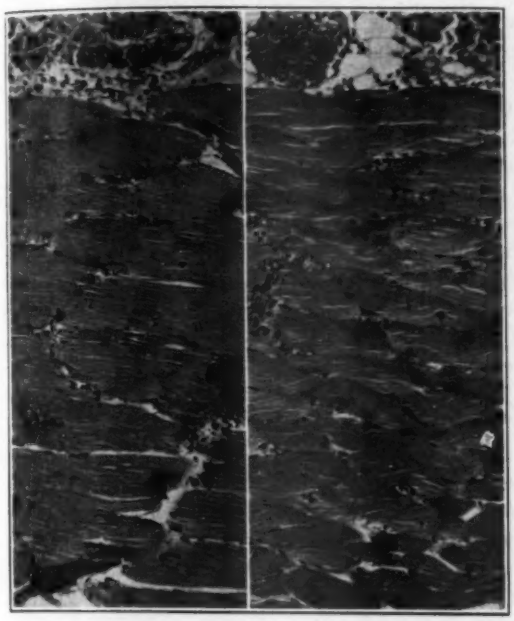


Fig. 2.—*Left:* Microscopic section from abdominal wall of rat in area denuded of skin and treated with isotonic solution of sodium chloride. The muscle remains normal and the overlying connective tissue persists. All sections taken twenty-four or forty-eight hours after application of test substances. *Right:* After application of petrolatum. Same result as from isotonic solution of sodium chloride.

Study of skinned abdominal walls of rats which are untreated or treated with isotonic solution of sodium chloride indicates that a thin layer of connective tissue remains overlying the muscle of the abdominal wall. After an animal is thus skinned, substances with much necrotizing effect penetrate this thin connective tissue layer and cause necrosis of the abdominal muscle. The degree of necrotizing effect can then be expressed by counting the number of layers of necrotic muscle fibers, observed microscopically. The muscle mass of the abdominal wall of the rats used averaged 40 muscle fiber layers, but varied in thickness from 31 to 58.

Table 1 gives the results. Six rats were used for each substance, killed at twenty-four or at forty-eight hours after the applications. The results were essentially the same whether examination was made after twenty-four or forty-eight hours. In those instances in which the depth of necrosis is given as zero there was no necrosis of muscle in any animal. When necrosis was present it

TABLE 1.—*Necrotizing Local Effect and Some Generalized Effects from Application of Various Substances to Rat's Abdominal Wall Denuded of Skin* *

	Depth of Necrosis No. of Muscle Fiber Layers, Average	Comment
Nothing applied	0	
Isotonic solution of sodium chloride	0	
Boric acid ointment (U. S. P.)	0	
Petrolatum (U. S. P.)	0	
Motor oil (Esso no. 3)	0	
Benzene	0.5	Muscular tremors for 30 minutes
Ether	0.5	Bleeding and reddening of treated area
White soap (Ivory)	0.5	
Hexylresorcinol	2.0	
Medicinal soft soap U. S. P. (50% aqueous)	2.0	
Alcohol 95%	3.0	Three died
Solution of hydrogen peroxide U. S. P. (50% aqueous dilution)	3.5	Application for 30 seconds only: 3 minutes caused death
Tannic acid 10%	6.0	Hepatic necrosis, central, in 4
Silver nitrate 10%	9.0	

* Each substance was tested on 6 rats.

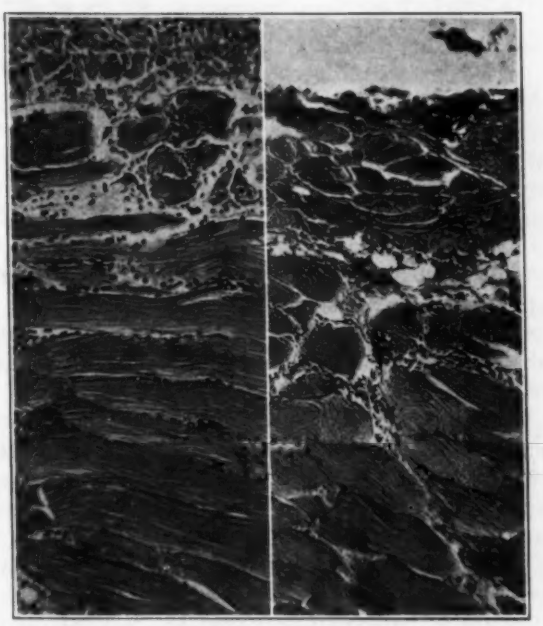


Fig. 3.—*Left:* Effect of medicinal soft soap U. S. P. (50 per cent aqueous). The two superficial layers of muscle fibers are necrotic, as shown by hyaline and vacuolar change and interruption of continuity of fibers. There is inflammatory reaction among necrotic fragments. The overlying connective tissue layer remains. *Right:* Effect of solution of hydrogen peroxide U. S. P. diluted to half strength with water. Necrosis, indicated by hyaline muscle fibers, extends to a depth of about six layers, deeper in this instance than the average noted in the 6 rats tested. The overlying connective tissue has been destroyed.

varied from rat to rat and occurred to varying depths in different parts of the section from the abdominal wall of the same rat. For example, the six rats treated with medicinal soft soap U. S. P. (green soap) showed necrosis to a depth of 1, 2.5, 1, 2, 3 and 2.5 muscle fiber layers respectively. Likewise, the six rats treated with ether showed necrosis to a depth of 0.5, 0.25, 0.1, 0, 1 and 2 muscle fiber layers respectively.

Death occurred spontaneously only in those rats treated with 95 per cent alcohol. Instead of recovering promptly from the ether anesthesia, these rats remained stuporous for several hours or until death, and it is supposed that the absorption of alcohol was sufficient to cause death. Alcohol levels in the blood were determined by Dr. Haywood Taylor in 6 additional rats, 3 treated with 95 per cent alcohol and 3 with isotonic solution of sodium chloride; and samples of blood were taken two hours after application of the substance.

TABLE 2.—*Alcohol Content of Blood from (a) Rats Treated with 95 Per cent Alcohol Over Area Denuded of Skin as Compared with (b) Rats Treated with Isotonic Solution of Sodium Chloride Over Similar Areas* *

Rats treated with alcohol	530.1 mg. per 100 cc. 369.9 mg. per 100 cc. 441.4 mg. per 100 cc.
Average	447.1 mg. per 100 cc.
Rats treated with saline solution	29.9 mg. per 100 cc. 21.2 mg. per 100 cc. 12.8 mg. per 100 cc.
Average	21.3 mg. per 100 cc.

* The figures indicate the high absorption of alcohol into the blood stream from body surfaces denuded of skin.

The figures in table 2 indicate the great absorption of alcohol into the blood stream from areas denuded of skin.

In addition to the muscular tremors of the animals treated with benzene, it was noted that rats placed in a closed container could be readily killed by the fumes of benzene, and would sometimes die if treated in a shallow pan.

The fatal effect of application of 50 per cent solution of hydrogen peroxide U. S. P. (i. e., solution of hydrogen peroxide U. S. P. diluted with an equal amount of water) to the skinned area for the full three minute period was corroborated in 6 additional rats, and dissection of the thoracic organs indicated that death was due to air embolism. Application to smaller areas, one-half or one-quarter as large, did not cause death. In Cushny's "Pharmacology and Therapeutics,"[5] it is stated that "the formation of emboli is seen most frequently in the rabbit, but was in all probability the cause of death in one case of fatal poisoning in man, in which a solution of hydrogen peroxide had been used to wash out the pleural cavity. Emboli are not formed in the dog on hypodermic injection."

No change in the internal organs could be attributed to any of the substances used except the hepatic necrosis produced when tannic acid was applied.

The necrosis of muscle at the site of application appeared to be due to the direct effect of the substance applied and not to overlying bacterial growth, since bacterial growth was superficial and was observed in the controls and in connection with substances which produced no necrosis of muscle.

REMOVAL OF PETROLATUM BY DETERGENTS

A series of experiments was carried out in which petrolatum was applied to the denuded area, allowed to remain for a time and then removed by various methods recommended in the literature for the removal of grease and oils from burns, following first aid or home treatment of burns and prior to definitive hospital treatment. Some of the methods suggested were as follows:

1. Wash with warm water and ether.
2. Use a mixture of medicinal soft soap U. S. P. and solution of hydrogen peroxide followed by hexylresorcinol.
3. Wash for ten minutes with soap and water or isotonic solution of sodium chloride.
4. Use ether or benzene followed by copious flushing with isotonic solution of sodium chloride.
5. Use 50 per cent medicinal soft soap (aqueous solution, not tincture) and a 50 per cent dilution of solution of hydrogen peroxide U. S. P.

The experimental animals were subjected to these treatments to remove the petrolatum. These substances removed the petrolatum with varying degrees of efficiency, but in so doing exerted the same untoward effects which have already been shown. It is to be realized, of course, that the experimental lesions were not burns but wounds and that the surface of a deep burn usually has a layer of necrotic tissue to begin with, as a result of the burn itself.

TANNIC ACID VERSUS TANNIC ACID-SILVER NITRATE

The same experimental method was used to compare the relative hazards of the tannic acid-silver nitrate treatment of burns and the tannic acid treatment of burns. To be determined were: (1) the degree of hepatic damage and

5. Edmunds, C. W., and Gunn, J. A.: Cushny's Pharmacology and Therapeutics, ed. 12, Philadelphia, Lea & Febiger, 1940, p. 790.

(2) the degree of necrotizing effect at the site of application. The tannic acid-silver nitrate combination was applied to 36 rats according to the following method: A freshly prepared aqueous solution of tannic acid was sprayed over the denuded area. This was followed immediately by spraying the area with a fresh mixture of equal parts of the aqueous tannic acid and 10 per cent silver nitrate solutions. This mixture was then sprayed on the denuded surface every ten minutes for a total of four applications. Tannic acid alone was applied for comparison to 36 more rats. This was applied by spray for a total of 5 applications exactly to duplicate the scheme of application of the tannic acid-silver nitrate mixture. The concentration of silver nitrate was kept at 10 per cent in all experiments, but that of tannic acid was 10 per cent, 15 per cent, and 20 per cent in the mixture in each dozen animals and in the control groups. Abdominal areas one eighth to one fourth of the total body surface were denuded of skin and treated by the tannic acid-silver nitrate method, by spray, and by the tannic acid alone in the controls.

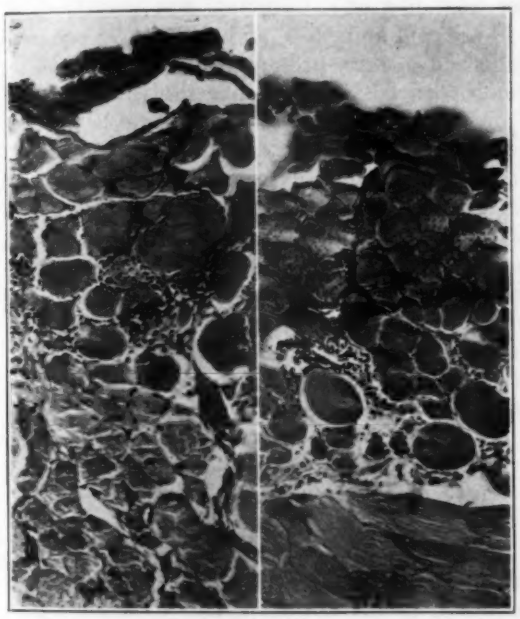


Fig. 4.—*Left:* Effect of 10 per cent tannic acid. Necrosis extends to a depth of six layers of muscle fibers, the average noted in 6 rats. The overlying connective tissue is necrotic. *Right:* Effect of 10 per cent silver nitrate. Necrosis extends to a depth of about twelve layers of muscle fibers, deeper than the average noted. The outer half of necrotic muscle is blackened by the silver nitrate. The most superficial fibers are muscle, and the overlying connective tissue has come away.

Damage to the liver was usually absent histologically when the tannic acid-silver nitrate solutions were used, while such damage was usually present when the tannic acid alone was used. Some damage was produced when concentrations of tannic acid as high as 20 per cent were used in combination with silver nitrate.

Of the 36 rats treated with tannic acid-silver nitrate none had died before the termination of the experiment at forty-eight hours, while of the 36 rats treated with tannic acid alone 10 rats had died before the end of that period.

Sections of the area of application of the test substances indicated that the combination of tannic acid and silver nitrate was essentially as damaging to the muscle of the rat's abdominal wall as the tannic acid, the combination producing necrosis of eight layers of muscle fibers and the tannic acid alone necrosis of nine layers of muscle fibers. The escharotic effect was exhibited to the same degree whether the concentrations used were 10, 15 or 20 per cent.

Thus the silver nitrate-tannic acid treatment appeared to be superior to the tannic acid treatment in rats, with respect to hepatic damage and to mortality, but there was no difference with respect to the local necrotizing effect.

TRIPLE DYE

Similarly "triple dye," frequently used in the treatment of burns, was subjected to experimental analysis. Aqueous triple dye solution (1.5 per cent methylrosaniline chloride, tetraethyldiaminotriphenylmethane sulfate [brilliant green] and 0.75 per cent acriflavine) was swabbed on the area denuded of skin. Three or four applications were made in a few minutes, with drying allowed between the applications.

Of 10 rats treated with triple dye 7 died before the end of forty-eight hours, while of 10 control rats treated with isotonic solution of sodium chloride none died. In neither group were visceral changes noted microscopically. The animals treated with triple dye were stuporous in comparison with those treated with the isotonic solution of sodium chloride. Necrosis of muscle where the dye was applied occurred to an average depth of 8.5 muscle fiber layers, while there was no necrosis of the muscle in the rats treated with the sodium chloride.

To test further the question of the generalized toxic effect of triple dye, subcutaneous inoculations of the dye were made. Ten rats withstood 2 cc. Of 3 rats receiving 1, 2, and 4 cc. respectively, the one receiving the 4 cc. died. The area of subcutaneous inoculation showed massive edema and necrosis microscopically.

Various experiments were performed to determine whether the rats treated over the skinned areas may have absorbed dye by licking the

treated area or whether the stuporous rats failed to take sufficient water to maintain body fluids. These experiments were not conclusive for one reason or another.

The definite conclusion was that triple dye exerted a considerable necrotizing effect locally. While there was some evidence to suggest that triple dye had a deleterious general effect, further evidence was needed before a conclusion could be drawn.

COMMENT

The experimental results show some of the effects on rats following the use of substances which have been applied to large burns or to wounds in human beings. These results indicate that several substances have a necrotizing effect on raw muscle surfaces. Whether this necrotizing effect is sufficient to constitute a contraindication to their use in a human being will depend on the circumstances in the case. In order to avoid this necrotizing effect on muscle, and probably on most other subepidermal tissues, nothing should be applied, or else such substances as isotonic solution of sodium chloride, petrolatum or boric acid ointment should be used. If it is necessary to cleanse the area with substances other than isotonic solution of sodium chloride a substance with slight necrotizing effect should be employed. Of the three substances with the same slight necrotizing effect white soap would appear to be preferable, since ether produced bleeding and reddening of the treated area and there is also the not unimportant danger of inflammability. Benzene, because of toxicity when absorbed from the surface area and by inhalation, is less desirable. The greater necrotizing effect of such substances as hexylresorcinol, medicinal soft soap, alcohol and solution of hydrogen peroxide make their use distinctly less desirable. Escharotics such as tannic acid solution, tannic acid-silver nitrate solutions or triple dye solutions should be used only with the realization that they are damaging to normal muscle tissue. Under certain circumstances the latter substances may prove injurious by absorption into the body.

The present study does not concern itself with the effect on the rate of healing of wounds, but it is probable that necrosis would delay it.

SUMMARY

Various substances which have been applied to human burns and wounds were utilized on rats as test animals and their local and general effects noted. No necrotizing effect on the exposed muscle of the rat's abdominal wall was seen when nothing or when isotonic solution of sodium chloride, petrolatum, boric acid ointment or motor oil (Esso no. 3) was applied.

White soap, ether and benzene had a minimal but definite necrotizing effect, involving the superficial muscle fiber layer; while hexylresorcinol, solution of hydrogen peroxide U. S. P. (50 per cent dilution), medicinal soft soap U. S. P. (50 per cent aqueous), and alcohol (95 per cent) produced a more pronounced necrosis involving the superficial 2 to 3.5 layers of muscle fibers. Tannic acid 10 per cent, silver nitrate 10 per cent, mixtures of tannic acid and silver nitrate and "triple dye" were extremely damaging to rat muscle, to a depth of six to nine layers of muscle fibers.

Absorption of certain of these substances by the large ventral areas denuded of skin was sufficient to cause death; specifically, alcohol (95 per cent), causing acute alcoholism, and solution of hydrogen peroxide U. S. P. (half strength), causing gaseous cardiac embolism. The absorption of benzene caused muscle tremors. Lethal anesthesia resulted if the rats breathed any great quantity of the benzene. Absorbed tannic acid produced hepatic necrosis.

These results indicate possible untoward effects of various substances which have been employed as therapeutic agents or as detergents on human burns or wounds.

On the basis of these tests on rats detergents should be avoided, but if they must be used white soap and ether are the least objectionable of those tested. White soap has the advantage, in comparison with ether, that it is not inflammable.

Mrs. Margery Prindle, M.A., assisted in this study.

NAVAL CASUALTIES IN A BASE HOSPITAL IN THE SOUTH PACIFIC

LIEUTENANT GEORGE CRILE (MC), U.S.N.R.

The treatment of choice of wounds depends largely on the speed with which facilities adequate for definitive treatment can be made available. Surgeons may report excellent results in the treatment of civilian casualties in metropolitan hospitals using methods that would not be applicable to field conditions. When the wounded can be taken immediately to a well equipped hospital or to an undamaged sick bay aboard a capital ship, radical excision of wounds and other operations may be feasible and successful. But in jungle fighting, hours or days may elapse before the wounded reach a field hospital, which usually not only is crowded but is often subjected to air raids or even to artillery fire. Similarly, if the ship aboard which casualties occur is subsequently sunk, the wounded may float for hours before being rescued by a destroyer, whose sick bay may already be filled to overflowing and whose one medical officer has more than he can do. Since a majority of the injuries that I saw were sustained aboard ships that were sunk or during action on land where prompt access to a well equipped hospital was not available, any conclusions drawn from the course of these patients must be interpreted not as being in conflict with reports from other areas but as being applicable to the type of casualties which occurred early in the Solomon Islands campaign.

EVALUATION OF EARLY TREATMENT

The patients received from the combat zone did not arrive at the Naval Hospital in Auckland, New Zealand, until twelve days or more had elapsed since they were injured. During the first few weeks of the campaign, before hospitals were in operation on islands nearer to the front, patients were received directly from hospital ships without previous hospitalization. During this period my colleagues and I saw a true cross section of casualties from the Solomon Islands, an opportunity denied us when hospitals in the north began, quite rightly, to hold over the most seriously wounded for supportive treatment before transferring them to us. Although we had no opportunity for treating freshly wounded patients, we perhaps were better able to evaluate the results of the initial treatment than were those who gave it and subsequently lost track of their patients through evacuation.

From eight to thirty-six hours usually elapsed before the patients reached a place where facilities for definitive treatment were available. At this stage infection was the greatest problem. Most compound fractures and many of the more severe flesh wounds of the extremities had been immobilized in plaster. A majority of these wounds did well when no attempt had been made to close them. However, wounds that had been treated by excision or radical débridement together with primary closure were nearly always badly infected, and it was necessary to open and drain those wounds which had not already broken open. These infections were among the most severe that we saw.

Wounds that had been widely débrided or excised without closure usually did not become infected, but the incidence of infection did not appear to be any lower in this radically treated group than in those in which little or no débridement had been carried out. Incisions made by excision of the wounds tended to gape widely and left large defects which subsequently had to be covered with a skin graft. Since little or no advantage was gained by these operations, and since the incisions increased the deformity and prolonged convalescence, conservative débridement or no débridement coupled with the liberal use of sulfonamide compounds seemed to be the treatment of choice. In most cases this technic was used, and the incidence of gas gangrene appeared to be no higher than when more radical procedures were used. In fact, no gas gangrene was seen in the first 500 or 600 patients treated.

Wounds in which metallic foreign bodies were present healed promptly and with little tendency to infection, although if the foreign bodies were over 2 cm. in diameter or located near the surface, a clean draining sinus was apt to persist. Here it was simple to remove the foreign body

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through the sinus tract without use of anesthesia following which the sinus closed spontaneously. Foreign bodies up to 2 cm. in diameter embedded in muscle produced no symptoms, unless they impinged on nerves or were in the proximity of joints. Therefore the immediate removal of deeply embedded foreign bodies was not essential, particularly if the procedure threatened to introduce infection into the depths of a relatively clean wound. Nonmetallic foreign bodies, usually bits of clothing, were either discharged spontaneously or were removed through the sinus along with the metal that carried them in.

The painful dressing of the stumps after amputation often presented a difficult problem. Most of the amputations were of the guillotine variety, and too often the skin flaps had retracted so far that it was not possible to pull them down over the raw stump. This situation could be attributed partially to the impossibility of maintaining adequate skin traction during the patient's transfer and partially to the sacrifice of too much skin at the time of operation. The desirability of saving long skin flaps in the case of patients who were to be transported without application of traction was at first not sufficiently appreciated.

Burns that had been treated by tannic acid or other eschar-producing substances were usually infected. Both healing and skin grafting were delayed as compared with those treated by sulfonamide ointments and pressure dressings. The results obtained by the open treatment of burns were far superior to those that followed the use of eschar-forming substances. It was also shown statistically that the incidence of infection was lower in burns treated by the local application of sulfonamide compounds than in those treated with these drugs given only by mouth.

TREATMENT OF INFECTION

Although the incidence of gross infection in flesh wounds and compound fractures was only 12 per cent and 14 per cent respectively, the treatment of infected wounds constituted our greatest problem. These wounds were treated initially by the local application of sulfonamide compounds, and the majority of the patients also received sulfathiazole by mouth. Consequently, when the patients reached Auckland infections that would respond to sulfonamide therapy were under control, and only those resistant to such therapy remained.

These cases could be roughly divided into two categories: first, those in which the infecting organism was resistant to sulfonamide therapy, and second, those in which mechanical factors in the wound prevented drainage and allowed pus to accumulate and neutralize the effects of the sulfonamide preparations. In the latter group the establishment of adequate drainage, either by irrigation with a catheter or by conservative surgical revision coupled with continuation of sulfonamide therapy, usually resulted in the prompt subsidence of the infection. The following principles were applied to the treatment of infected wounds.

Immobilization.—If fever or pain suggested infection in a wound immobilized in plaster, the cast was bivalved, the wound was examined to make certain that no abscess or pockets were forming, and the same cast was then reapplied. If the wound was not immobilized in plaster, a splint was applied. If the temperature was elevated or if there were local indications of cellulitis, the wound was examined every three or four days, care being taken to prevent motion of the part. Provided that no abscess or pocket was present, patients did better with immobilization and infrequent dressings than with intensive treatment.

If mechanical factors blocking drainage were present, a conservative surgical revision was performed.

Wet Dressings.—Efficient drainage was provided by wet dressings. By catheters incorporated in the dressings, the wound could be irrigated without moving the extremity or changing the dressings. Secretions from the wound soon coagulated on dry dressings and blocked further drainage. Similarly, packing the wound open with gauze did not provide satisfactory drainage, unless the gauze was kept saturated to prevent coagulation of secretions.

No Dressings.—Certain wounds around the buttocks and rectum were difficult to dress and were subject to contamination by feces. To avoid the discomfort and activity involved in the frequent changing of dressings, patients with wounds of this type were allowed to lie on wax paper, which could be changed as often as necessary with a minimum of discomfort. When fecal fistulas draining posteriorly were present, the patients were placed on Bradford frames and bedpans were placed beneath the frames to catch the discharge. The wounds healed as cleanly without dressings as those which one attempted to keep covered with clean dressings.

Painful wounds, especially of the hands, and raw amputation stumps, to which gauze invariably adhered and caused much pain, were often covered with sterilized cellophane from packages of cigarets.

Sulfonamide Compounds.—A majority of the infections were resistant to sulfonamide preparations, either because of local conditions or because of the type of infecting organism. Therefore these drugs were given by mouth only when the patient showed an elevation of temperature or other evidence of a spreading infection. We used both sulfanilamide and sulfathiazole locally and could see no difference in the efficacy of the two compounds.

The fact that certain infections did not respond dramatically to sulfonamide therapy should in no way reflect on the efficacy of the drugs. Patients were treated with sulfonamide compounds for ten days or more before they reached our hospital, and the value of these drugs was expressed more in the low incidence of infection than in their effect on infections which had already developed.

There is no danger of overabsorption of the sulfonamide preparations from a granulating surface. Only when the drugs are used in extensive fresh burns or are implanted in the peritoneal cavity does this danger exist.

Patients are rarely sensitized to sulfonamide compounds given by mouth. But when they are applied to a raw surface over a long period many patients become sensitized. If a patient has been sensitized by the topical application of one of the sulfonamide drugs, its administration by mouth or to a wound causes a rash to appear promptly at the site of the original application. The rash usually spreads rapidly to involve the entire body and may be accompanied by fever. When the reaction is localized, the rash and fever may simulate lymphangitis and prompt the physician to give increasing amounts of the drug until the true nature of the complication is recognized.

Operation.—Few infected wounds required surgical treatment. Deep abscesses were rare, and the only foreign bodies which caused significant reaction in the tissues were the nonmetallic ones or occasionally pieces of aluminum. Frank suppuration was usually present about nonmetallic foreign bodies and it was a simple matter, usually without anesthesia, to grasp them with a hemostat and withdraw them through the sinus tract. Similarly, bits of shrapnel that caused persistently draining sinuses could usually be felt with a probe and withdrawn with a hemostat without undue discomfort to the patient.

Large subcutaneous or intramuscular pockets were treated satisfactorily by (1) immobilizing the part, (2) inserting a catheter into the pocket, (3) irrigating the wound through a catheter every two hours day and night with sulfanilamide suspended in a 1:500 solution of chloroazodin (azochloramide) and (4) applying a pressure dressing after forty-eight hours of irrigation. Often when the catheter was removed after four or five days only the sinus tract remained.

A wound which does not respond within a week to intensive treatment with sulfanilamide suspended in chloroazodin solution will probably never respond to that form of therapy. In these cases surgical measures were no longer deferred, and the pocket was opened and packed open. Skin was never sacrificed unless the infection was of a burrowing necrotizing type. When the skin was conserved most wounds could be closed without utilization of grafts. Although defects left by this procedure often required secondary closure, this was preferable to a prolonged period of drainage from a chronic abscess.

SECONDARY CLOSURE

The rate of healing of wounds varies greatly in different patients. This variation appeared to be related to factors other than the presence of gross infection or to a deficiency of vitamin C. The factors which influence the rapidity with which a clean wound closes of its own accord have not been determined.

Wounds close by contraction and by epithelization; these processes go on at various rates in different persons and in different locations on the same person. Wounds of the leg, particularly over the tibia, and wounds about the hip are usually slow in closing. An underlying bone, such as the tibia, seems to interfere with contraction of the wound and the blood supply necessary for growth of epithelium. The difficulty of immobilizing the hip without using a body cast may be responsible for failure of wounds of the hip to heal.

The size of a wound does not necessarily determine the advisability of closing it. In general, wounds over 2 inches (5 cm.) in diameter should be closed, but occasionally a wound of this size will contract and epithelize so fast that spontaneous healing will occur nearly as rapidly as solid union after closure. On the other hand, many wounds only one-half inch (1 cm.) in diameter may reach a stage of complete equilibrium in which no further contracture or epithelization takes place. This situation usually occurs in wounds over the tibia, but may occur in any wound of long duration when the blood supply and ability to contract are limited by a base of dense scar tissue.

Since at first glance it is impossible to tell whether a wound will heal spontaneously or whether operative treatment will be necessary, a wound should be observed for a week before

closure is advised. During this time any residual infection can be cleared up so that the operation may be performed in as clean a field as possible. Many fresh wounds which at first seemed to require closure will have healed so fast during this period of preparation that operation will not be necessary.

On the other hand, if a small wound, even ½ inch or less in diameter, reaches a stage when its edges appear totally inactive and when it has remained the same size for a week or longer, time will be saved if a secondary closure is done immediately. The time for closure may be determined only by observing the wound and noting its failure to make progress under adequate conservative treatment.

In general, wounds do not show a maximum healing tendency until two weeks after they have been sustained. By this time the infection usually has subsided, and the wound is granulating cleanly and beginning to contract and epithelize. If a wound is two or more months old, it will rarely exhibit a dramatic healing tendency and will often develop the chronicity of an ulcer. Therefore it is a good rule to act promptly in closing old wounds, and to delay in closing small wounds of recent origin. Fresh wounds of large size heal according to the law of diminishing return; the wound may heal rapidly at first and then, as scar tissue forms at the base and impedes circulation and contraction, the wound may heal more slowly, or may never heal. It is unwise to expect the rapid spontaneous closure of a large wound, no matter how fast at first it may appear to be closing.

Secondary Closure vs. Skin Grafts or Spontaneous Epithelization.—Whenever possible, closure of a defect by suture is preferable to the grafting of skin. After closure, the surface is composed of normal skin and subcutaneous tissue and is much more resistant to trauma than is even a thick skin graft. Closure reduces scarring, and if the deeper tissues are not injured the patient is fit to return to duty as soon as the wound is solidly healed. A skin graft must be protected from trauma for weeks or even months and may never afford an entirely satisfactory surface in locations subjected to weight bearing or trauma.

Extensive scarring, resulting from spontaneous epithelization, is similarly undesirable. The epithelium is thin and lacks the supportive structures of normal skin. The slightest trauma may cause this type of epithelium to break down repeatedly, or if the scar is at a joint, its contraction may limit motion. Secondary closure therefore is the treatment of choice for all large wounds which will heal with a broad scar that might be the site of future trouble.

It is difficult to decide when to graft skin and when to close a wound by suture. In most wounds the defect in the skin is more apparent than real. The same elasticity of the skin which results in wide separation of the wound edges, particularly after radical débridement, often allows it to be closed again by suture. However, when skin has been avulsed by shell fragments in wounds of exit, or when primary closures have broken down with loss of the skin edges, the defect may be too large to close without grafting. Here grafting should be deferred until the wounds is clean, and until all sinuses have filled. After suitable preparation of the surface, a split-thickness skin graft should be applied.

The success of a secondary closure depends primarily on the ability of the surgeon to immobilize the part and to apply an efficient pressure dressing. If a snug pressure dressing can be applied by a circular elastic bandage, wounds of the arms or legs can be closed even under considerable tension. Wounds about the hip, however, are subject to motion with every movement of the trunk or legs, unless a spica cast is used, and pressure is difficult to apply. If there is much tension in an area subjected to motion, the sutures tend to cut through and the wound edges to separate, resulting in a failure of the closure. Consequently, although wounds of the legs or arms under extreme tension may be closed by sutures, wounds of the hip should be covered with skin grafts unless the skin edges can be brought together with ease.

Wounds of the muscular portions of the legs or arms can be undercut widely so that the edges can be approximated, and firm pressure dressings applied without jeopardizing the circulation of the skin flaps. Wounds over the tibia must be treated more carefully, for if the skin flaps are widely undermined the pressure of the dressing against the tibia may cut off the circulation and cause necrosis of the skin edges.

Similarly, when a flap is to be swung from the side of the leg over the tibia, it should first be elevated and replaced in its bed for two weeks before final transfer is effected. The circulation of the skin of the leg is not so good as elsewhere, and when flaps are longer than the width of their bases, it is safer to transfer them in stages.

Technic of Secondary Closure.—If a defect is to be covered with a skin graft, the surface should be as clean and the granulations as healthy as possible. If the wound is to be closed, however, it is not so important for the granulations to

be flat and red as if a graft were to be applied. Although a closure usually can be accomplished successfully in the presence of considerable discharge, there should be no unclosed sinus tract leading to a pocket from which infection can spread and involve the entire wound. Preparation for secondary closure of a clean granulating wound usually consists of sprinkling sulfanilamide powder on the wound twice daily for two days and applying a pressure dressing saturated with chloroazodin solution.

The operation is performed with the patient either under local anesthesia or under anesthesia with pentothal sodium and consists of the following steps:

1. Granulation and scar tissue is excised down to normal muscle or fat. When nerves, vessels, tendons or other important structures are in the vicinity only the granulations are shaved away. Although the results seemingly are not so good as when scar tissue is completely excised, the number of failures does not warrant the risk of damaging important structures.

2. The skin is undercut sufficiently to accomplish satisfactory closure.

3. Hemostasis is obtained chiefly by pressure dressings; no attention is paid to venous or capillary oozing. Spurting arteries are ligated with no. 50 or 60 cotton. No catgut is used because it tends to cause reaction in the tissues and result in the development of infection. Few or no ligatures are used, and in our experience there has been no difficulty with cotton being discharged from these wounds.

4. The entire wound is dusted with sulfanilamide powder.

5. The skin edges are approximated with vertical mattress sutures of no. 32 stainless steel wire by taking large bites. No rubber gauze or other material is placed between the loops of the sutures and the skin to prevent the wires from cutting through. Wire with the aid of a pressure dressing holds the skin together long enough to insure adherence of the edges; if the wire does cut through, only small vertical slits are left instead of large areas of necrosis resulting from pressure of the material designed to keep the wire from cutting. Moreover, the circulation of the skin edges is not jeopardized by the pressure of broad pieces of rubber under the wire loops. Therefore in wounds closed under extreme tension it seems preferable to accept the cutting of a small loop of suture rather than to jeopardize the circulation of the entire edge of the wound with pressure from various devices designed to prevent the sutures from cutting.

6. If considerable oozing is present or if the wound is grossly contaminated, a small rubber drain is inserted through the skin edges at the dependent part of the wound.

7. A gauze dressing is applied to the wound, and over this sterile mechanic's waste (cotton) is placed to assure an even distribution of pressure. Pressure is then applied with a woven elastic bandage.

8. If the wound involves a joint, the joint is splinted to insure absolute immobility.

9. The wound is inspected for the presence of infection after five days; if it is healing well, the pressure dressings and splints are reapplied. The sutures are not removed for two or three weeks, even if they tend partially to cut through the tissues.

The incidence of infection in these cases is low and the results when pressure and immobilization can be maintained are good even when the wounds are closed under great tension.

FOREIGN BODIES

Indications for Removal.—Many metallic foreign bodies cause no symptoms. If they are not (1) over 2 cm. in diameter, (2) located in the region of a joint, (3) impinging on a nerve, (4) located subcutaneously or (5) causing a draining sinus, they may remain embedded in the tissues indefinitely without causing trouble. This is particularly true if the patient is not aware of their presence. The deeper a foreign body is embedded the less apt it is to cause symptoms. Foreign bodies over 2 cm. in diameter, even when deeply embedded in muscle or fibrous tissue, occasionally cause symptoms requiring their removal.

Foreign bodies located directly under the skin are often palpable, and since they are readily removed, it is wise to do so. Superficially located foreign bodies are more apt to cause persistently draining sinuses. Occasionally their proximity to a joint necessitates their removal.

When a patient complains of pain in an extremity and a roentgenogram shows a foreign body embedded in the tissues, a logical assumption is that the pain is caused by the foreign body. However, this is rarely the case. The pain is usually the result of a traumatic neuritis and is not related to the metallic fragment. When a nerve has been damaged or cut, a traumatic neuritis ensues, and for weeks or months pain may be referred to the distribution of that nerve. Most patients who complain of pain in an extremity and who show no evidence of infection have sensory changes in the skin corresponding to the distribution of one of the sensory nerves. Hyperesthesia, hypesthesia or anesthesia may be present, and careful roentgen studies usually will show that the foreign body is not located anywhere near the course of the nerve supplying the area to which the pain is referred. Under these circumstances, removal of the foreign body is not indicated; time will heal the symptoms of injury to the nerve. The less the patient knows about the presence of the foreign body, the more apt the symptoms are to subside promptly.

Technic for Removal of Foreign Bodies.—Both anteroposterior and lateral roentgenograms should be used to locate foreign bodies accurately before their removal is undertaken. If a report

on a roentgen examination states that a foreign body 2 cm. in diameter is present in a certain location in which a mass is palpable, one might assume that the palpable mass is the foreign body. Too often a tiny foreign body, the size of a grain of wheat, is surrounded with a hematoma which causes the palpable mass, while the large foreign body which is to be removed is located elsewhere. A small foreign body traveling at high velocity may penetrate a bone without fracturing it and may leave a palpable area of reaction along its course, so that the impression is given that the foreign body is palpable over the bone. For this reason, skin markers or fluoroscopy should be used, and anteroposterior localization should be carried out. The two needle system of localizing a foreign body may also be of value.

Through the courtesy of an Army General Hospital we had access to a Burman Locater, an instrument which indicated the location of a metallic foreign body. The instrument is so large, however (its point is nearly the size of a thumb), that it is not of much value in locating the small foreign bodies that are the most difficult to find. The instrument is of unquestionable value in locating larger foreign bodies deeply embedded in the tissues and has proved to be a useful adjunct to roentgenography and fluoroscopy. In locating smaller fragments, the fluoroscope is of the greatest value.

BURNS

Initial Treatment.—During the first year over 200 patients with burns were treated at our hospital. Only a few of these burns were fresh, the majority being from ten days to three weeks old. In the beginning nearly all burns had been treated with tannic acid. Later the majority had been treated with sulfonamide ointments and pressure dressings. The results of treatment with sulfonamide ointment were incomparably superior to those obtained with eschar-forming substances. The incidence of infection was lower, and grafting of skin could be done much earlier. It made little difference which sulfonamide compound was applied if the burn was considered to be a contaminated open wound and no eschar-producing substance was used. Our preference for the initial treatment of burns was sulfathiazole ointment and pressure dressings, the initial dressings being left on for a week or more unless evidence of sepsis developed.

Treatment of Infected Burns.—Infection was the greatest problem in the majority of burns at the stage in which we saw them. Nearly all third degree burns and about 20 per cent of second degree burns treated with tannic acid were grossly infected.

Dressings and soaks with 1:500 aqueous solution of chloroazodin and saline solution were most effective in softening eschars and controlling infection. As soon as the eschars could be removed intensive treatment was commenced to control infection and to prepare the surfaces for skin grafts.

Preparation of the Wound for Grafting.—[I quote from an earlier article.[1]] The use of the sulfonamides alone does not always clean up the infection and prepare the granulating surface for grafting. Often the granulations remain boggy and edematous and continue to be covered with purulent exudate in spite of the daily application of either sulfanilamide or sulfathiazole powder. The combined use of moist saline dressings and sulfanilamide resulted in striking improvement of many of these wounds, but the best results were obtained when the wounds were:

1. Sprinkled with sulfanilamide.
2. Dressed with fine-mesh gauze saturated with a 1/500 solution of azochloramide in glyceryl triacetate.
3. Covered with gauze dressings saturated with saline.
4. Bandaged with an elastic bandage to give pressure.
5. Kept moist with saline injected into the dressing through catheters.

Moreover whenever the burn was on an extremity, this was elevated to afford dependent lymphatic drainage. Forty-eight hours after this type of dressing was applied usually there was produced a clean, firm, red, granulating surface on which skin could be grafted without necessitating cutting off the granulations. The dressings were usually changed only twice during this forty-eight hour period.

Sulfanilamide, when not inhibited by the presence of pus and products of proteolysis, will quickly clean up most infections that may be present on a granulating surface, but if pockets, recesses, or sinuses in which pus can form are present sulfanilamide will be inactivated and the infection will persist.

The combined use of sulfanilamide and azochloramide [chloroazodin] appeared to be much more effective than the use of either drug alone.

The pressure dressings not only reduce the amount of exudate and thus decrease the inhibitory effect that this exudate will have on the sulfanilamide, but also reduce the edema of the granulations and make them firm, vascular, and ready for grafting.

The moist dressings prevent caking of the sulfanilamide powder and allow free drainage of the exudate. If dry dressings are applied they soon trap further secretions beneath an impervious layer of caked exudate and thus inhibit the activity of the sulfanilamide.

If the extremity is elevated, gravity aids in reducing the edema of the granulations, and the exudate appears to diminish in amount. It is thus clear that each step in this plan of treatment plays a part in diminishing or removing the exudate or in neutralizing its inhibitory effects on the activity of the sulfonamides.

1. Crile, G., Jr.: Experiences of Surgical Service of United States Naval Hospital, Auckland, New Zealand, with Casualties from Initial Solomon Islands Engagement, U. S. Nav. M. Bull. **41**:306 (March) 1943.

The oral administration of the sulfonamides did not seem to be of any particular value in the treatment of infections in which pus had formed beneath eschars.

In many cases, changing dressings is a painful procedure, especially when the burns involve the hands. Even moist fine mesh gauze tends to adhere to the raw surfaces and not only causes pain but also destroys the young epithelium. Although with perfectly clean lesions petrolatum gauze or ointments of various types do not have the liabilities of gauze, neither petrolatum nor any ointment allows free drainage of the secretions. When drainage is blocked, pus accumulates, granulations become boggy and edematous, the efficacy of a sulfonamide compound is reduced by the presence of peptones, infection does not clear up, and the area cannot be rendered clean enough to apply a graft. Petrolatum or any oily substance converts an infected surface into an abscess, one wall of which is the granulating surface and the other the gauze impregnated with petrolatum. A dressing is needed which will afford drainage and at the same time will not adhere sufficiently to cause pain or to damage young epithelium when it is removed. Such a dressing was suggested by Callahan,[2] who used an absorbent cellulose compound, "Kleenex." Kleenex can be autoclaved and applied directly to open wounds or raw surfaces. It is extremely absorbent, allows free drainage of secretions if dressings are kept moist and is practically nonadherent. If it does tend to adhere, moistening causes almost complete dissolution of its fibers. Pain and damage to tender epithelial strands can be prevented if this type of dressing is used on burns.

For badly infected lesions irrigations with a saturated solution of sulfanilamide are alternated with chloroazodin solution. Once or twice a day a solution of 1 per cent acetic acid is introduced to control any infection with Bacillus pyocyaneus. But the most important feature of the preparation of the area for grafting of skin is the application day and night of wet pressure dressings which are never allowed to dry.[3]

PENETRATING WOUNDS OF THE CHEST

Most penetrating wounds of the chest produced a hemothorax or hemopneumothorax. These complications were usually mild and soon cleared up spontaneously, especially when the wound was inflicted by the small caliber Japanese bullets. The incidence of empyema in these cases was low.

Empyema almost always developed in large sucking wounds of the thoracic wall produced by shell fragments. The foreign bodies rarely lodged in the pleural cavity or lungs, but usually either penetrated both walls of the thorax or after traversing the pleural cavity came to rest in the opposite thoracic wall.

Hemothorax was treated conservatively. The patients were confined to their beds, and sulfathiazole was given by mouth. The blood was not aspirated unless (1) the patient became dyspneic, or (2) persistent, steadily rising temperature and evidence of sepsis indicated the development of infection.

The incidence of empyema was low (probably not over 10 per cent). There were no fatalities from empyema although the entire pleural cavity was usually involved. The average patient with a large hemothorax may have a temperature as high as 103 F. for two or three weeks, suggesting the presence of empyema. At the end of this time, the temperature may begin to subside spontaneously and return to normal levels in four or five weeks. Therefore either open or closed drainage of a hemothorax should be postponed until repeated cultures of fluid aspirated from the chest have indisputably proved the presence of infection.

In empyemas resulting from wounds the fluid does not contain as much fibrin as in postpneumonic empyemas, nor does the pleura or fluid thicken as rapidly. Therefore the fluid may be aspirated for a considerable length of time after infection develops. We did this in several instances and did not observe infection of the wall of the chest. It was my impression that by emptying the infected pleural cavity each day without introducing air it might have been possible to have decreased the size of the cavity which resulted when open drainage was finally established. When this can be accomplished, convalescence will be shortened unquestionably.

PENETRATING WOUNDS OF THE ABDOMEN

As a result of conditions of combat few patients with abdominal wounds were seen at the base hospitals. Operations to repair injuries of the bowel usually were done a number of hours after injury, and it was surprising that any of the patients survived. In most instances incisions had been closed with catgut, and almost without exception these wounds had become infected, and usually had disrupted. I believe that better results would have been obtained if the wounds

2. Callahan, G. B.: Burns Treated by Cod Liver Oil Treatment—Paper Tissue Dressing, Mil. Surgeon **92**:439 (April) 1943.

3. Full details of the routine used by the Burn Service under the direction of Lieutenant H. R. Yandell are pending publication in the U. S. Naval Medical Bulletin for April 1944.

had been closed with nonabsorbable suture material or had been packed open.

Most of the fistulas of the small intestine closed spontaneously. The same was true of a biliary fistula, presumably arising from the gallbladder. Frequently, injured segments of the colon had wisely been exteriorized, or a proximal colostomy had been performed. In these cases it was a simple matter to close and replace the colon.

INJURIES TO ARTERIES

Secondary Hemorrhage.—Bleeding may occur into a cast with no external evidence of hemorrhage except shock. As the patient himself is often unaware of the bleeding, this complication must always be suspected when a patient with a cast suddenly exhibits symptoms of shock.

Ligation of a vessel as large as the femoral artery when conducted in an infected field is usually doomed to failure. After three or four days the ligature is thrown off the artery and the bleeding recurs. Whenever possible the vessel should be ligated through a separate incision in a clean field. As a rule packing does not control hemorrhage from a large vessel for more than a few hours.

On several occasions we were surprised to find that bleeding from the infected wound persisted or recurred after proximal ligation of the main vessel through a separate clean incision. In these cases the distal end of the main vessel was bleeding by means of collateral anastomosis. Because the pressure in the distal end of the vessel is so low, simple ligation of the distal stump in the infected field permanently controls the bleeding.

Communicating Arterial Hematoma (Pulsating Hematoma).—When the wall of a vessel is not completely severed by a small projectile but has an opening in one side which is held open by elasticity of the vessel, blood escapes into the tissues. Clots block the wound of entry, and a pulsating hematoma is formed. The wound of entry soon heals over, and a hematoma remains which communicates with the artery. Clinically, this manifests itself by a tense, fluctuating mass which has an expansile pulsation if located superficially and over which a systolic bruit frequently can be heard. It is differentiated from an arteriovenous aneurysm by a bruit which is audible only in the systolic phase and by the absence of circulatory signs attending an arteriovenous fistula. Occasionally, when the hematoma is located deep under the muscles and fascia and when the opening in the vessel is small, there is no bruit or palpable pulsation; the diagnosis is established by inserting a needle and obtaining bright red arterial blood.

The hematoma is under full arterial pressure and gradually enlarges until it ruptures spontaneously through the skin, usually at the site of the wound of entry. The defect must be repaired before a severe secondary hemorrhage occurs. The treatment of choice is ligation of the vessel above and below the point of injury, division of the artery and ligation of its accompanying vein. Since it is often impossible to apply a tourniquet proximal to the lesion, it may be necessary to control bleeding by placing a tape around the vessel through a separate incision. In this event it is desirable also to place a tourniquet distal to the wound in order to control bleeding from the distal end of the vessel.

The sacs of the false aneurysms are not excised, but are merely sprinkled with sulfanilamide powder and then obliterated by very light pressure. The wounds heal promptly without infection or secondary hemorrhage.

Reconstruction of a vessel is rarely desirable since thrombosis or development of a true aneurysm frequently occurs. We had occasion to ligate the common carotid artery, the femoral, the subclavian and the axillary, and on two occasions both the femoral and profunda arteries, without observing serious impairment of the circulation.

Circulatory Disturbances Following Injury of Blood Vessels.—Damage to the great vessels, even in young people, may cause gangrene of the extremity, but in our experience this complication occurs only (1) when the wound is large and when much muscle and many collateral vessels are destroyed, (2) when severe infection and swelling interfere with collateral circulation or (3) when the injured artery is the popliteal. Since most communicating arterial hematomas are caused by small projectiles and since few are infected, maintenance of adequate circulation is not often a serious problem.

Impending circulatory gangrene of an extremity, resulting from extensive destruction of soft tissues and blood vessels, can be satisfactorily treated for several weeks by conservative means, if facilities are available for refrigerating the gangrenous extremity. During this time collateral circulation develops (aided, if desired, by injection of procaine hydrochloride into the sympathetic nerves and by the oral administration of alcohol), and the line of demarcation which then develops is often considerably lower than was initially expected. By keeping the gangrenous portion cool, infection can be retarded or prevented until collateral circulation

of the viable portion permits good healing after amputation. The gangrenous portion must be examined frequently for signs of infection.

Arteriovenous Fistula.—Repair of an arteriovenous fistula is not an emergency procedure. Unlike communicating arterial hematomas in which the sac expands under tension of full arterial pressure, the blood in an arteriovenous fistula is under low pressure and hence the aneurysm does not tend to rupture externally. The pressure is shunted off into the veins, and the only dangers are chronic circulatory disturbances in the extremity and overburdening of the myocardium.

Since blood pressure in the extremity is low as a result of deflection of arterial blood into venous channels, collateral circulation soon develops. Although most aneurysms could be corrected immediately by quadruple ligation of the vessels, it is wise to wait two or three months until collateral circulation has developed beyond the point of slightest question.

GAS GANGRENE AND TETANUS

Tetanus, to my knowledge, did not occur in the South Pacific area. The absence of tetanus can be explained by the fact that all men engaged were actively immunized with tetanus toxoid, and booster doses of toxoid were always given as soon as a wound was incurred.

Gas gangrene was not common. During the first six months we encountered no cases of gas gangrene, and in all only 15 or 20 patients proved to have such a condition were admitted to the hospital. Since some amputations were performed for suspected gas gangrene in forward areas, a statistical analysis of its incidence was impossible.

It was interesting that the incidence of gas gangrene was so low, because little gas gangrene antitoxin was used prophylactically in the first six months, and few of the wounds were radically débrided. From this it should not be inferred that débridement and prophylactic doses of gas gangrene antitoxin are not of value. Reports from other areas often indicate that the opposite is true. It is likely that the clean environment of ships and the lack of cultivation of the soil had as much to do with the low incidence of gas gangrene as did any therapeutic measures. But in connection with the prophylactic value of excision of wounds or radical débridement it is interesting to note that Major MacLennan, of the British Army, reports the incubation period of infections due to Clostridium welchii—from time of injury until development of clinical symptoms of infection—to vary from seven hours to three and one-half days, with an average of twenty-three hours.[4] Accordingly, one would scarcely expect wound excision, performed twenty-four hours or more after the wound is sustained, to effect any striking diminution in the incidence of gas bacillus infection.

Gas bacillus infection may vary in severity from (1) a very mild type, slow to develop, slow to spread, and easily controlled by removing the involved muscle bundles and affording adequate drainage, to (2) a fulminating variety, initiated by profound systemic symptoms and progressing, despite treatment, to prompt and certain death. Approximately one fourth of our cases were in the latter category.

In fulminating gas gangrene systemic signs may overshadow the local manifestations of the infection. Often the gas is not palpable in the tissues, and the odor is not detectable. Instead manifestations of shock first call attention to the seriousness of the patient's condition.

Shock develops because of diminution in blood volume. In fulminating gas gangrene infection, enormous amounts of fluid are lost into the tissues in the production of edema, and large quantities of serosanguineous fluid pour from the wound. When a wound begins to bulge and pour out serum, gas gangrene must always be suspected, as these are usually the initial signs. The presence of crepitus or of gas coming from the wound may be found only in the terminal stages.

As soon as gas gangrene is suspected, smears should be made. If characteristic bacilli are found, large quantities of polyvalent antiserum should be given without delay. After a corneal test for hypersensitivity, the serum should be given intramuscularly—some of it around the wound—in doses up to 100,000 units within four or five hours. In our experience the intravenous administration of the serum produced severe reactions and was discontinued.

Gas bacilli grow in dead tissue and produce a toxin that kills adjacent living tissue; they then spread to recently killed tissue, again forming toxin, and progressively involve more and more of the body. Since sulfonamide compounds have only a slightly inhibiting influence on the organisms, and since the drugs are blood borne and hence do not reach the areas of dead tissue in which the organisms are growing, not much reliance can be placed on their use. Roentgen therapy in our experience is of little or no value. The only hope is (1) to remove or drain the focus of infection and (2) to raise the antitoxin

4. MacLennan, J. D.: Anaerobic Infections of War Wounds in Middle East, Lancet (*a*) **2**:63 (July 17); (*b*) 94 (July 24); (*c*) 123 (July 31) 1943.

levels high enough to neutralize the toxins and prevent them from killing more tissue.

Organisms other than the gas bacillus can produce necrotizing infections of the muscle. Major MacLennan reported 8 cases of an anaerobic streptococcic infection of the muscle, which resulted in gangrene of the involved tissues.[4a] In a case that we observed several entire muscles of the forearm became gangrenous and were discharged from the wound. Cultures failed to grow the gas bacillus, and smears showed a predominance of streptococci. In such cases and also in cases in which air is blown into the tissues, gas bacillus infection may be erroneously suspected and amputation unwisely performed.

TROPICAL DISEASES

Tropical Ulcers.—The causation of tropical ulcers is not known. Following insignificant trauma, such as scratching a shin, bruising an ankle or an insect bite, a small ulcer develops. These ulcers become chronic and continue to enlarge in spite of seemingly adequate therapy. Even when treated intensively with bed rest, sulfonamide compounds and pressure dressings they often will stubbornly refuse to heal until the patient is evacuated from the tropics. Cultures taken after several weeks fail to reveal any specific organisms in the ulcer.

The majority of the ulcers were on the lower leg, usually over the tibia. Most of them had been present for two or three months, their bases were filled with edematous granulations and the epithelium was completely indolent, showing no tendency to grow over the surface of the ulcer.

The ulcers varied from 1 to 10 cm. in diameter, the majority measuring from 2 to 3 cm. Even in the temperate climate of New Zealand and when the patients were treated with rest in bed, sulfonamide drugs, chloroazodin solution and pressure dressings healing was apt to be remarkably slow. For this reason surgical measures was the treatment of choice in these cases.

The epithelium of an ulcer which heals spontaneously over a period of months is paper thin and is apt to break down under the slightest trauma. This is particularly true when the ulcer is over the tibia, a site having a poor blood supply and vulnerable to trauma. For this reason, and because of the time required for these lesions to heal spontaneously, the ulcer is excised and the defect is either closed or covered with a skin graft. When the ulcer is over the tibia and is too large to excise and close, a flap from the lateral surface of the leg can be swung over it, and the area from which the flap was taken can be grafted at the same time. A good base is thus afforded for the graft, and a good covering of skin and subcutaneous tissue is swung over the tibia. In lesions of the lateral parts of the leg subcutaneous tissue is usually sufficient to allow excision of the ulcer and immediate application of split-thickness skin grafts.

SUMMARY

No striking benefit is to be expected from radical débridement or excision of the wound when it cannot be done in the first few hours.

Wounds débrided and closed eight hours or more after they are sustained almost invariably become infected and break down.

Long skin flaps should be left when amputations are performed, especially on patients who are to be evacuated and on whom adequate skin traction cannot be maintained.

Infection is treated by the use of sulfonamide compounds and chloroazodin, revision of the wound is performed and the infected part is immobilized.

Early secondary closure is desirable, and the technic outlined may be used for accomplishing this.

The presence of metallic foreign bodies usually does not interfere with healing; when a draining sinus persists, the foreign body is easily removed through the sinus.

The results of treatment of burns with tannic acid are not as good as those obtained from the use of sulfonamide ointments and pressure dressings.

Infected burns should be prepared for grafting of skin as discussed, and wet dressings, sulfanilamide powder, chloroazodin and pressure dressings should be used.

Hemothorax usually absorbs spontaneously with no treatment other than with the sulfonamide preparations and bed rest.

Communicating arterial hematomas are treated by prompt ligation and division of the injured artery. Circulatory gangrene rarely follows ligation of the great vessels, unless collateral circulation has been destroyed or severe infection has occurred.

The incidence of gas gangrene is low, but approximately one fourth of the cases are of the fulminating type. Early surgical treatment and the prompt use of large doses of antiserum is the treatment of choice.

Early excision and closure of tropical ulcers is desirable.

COMPARATIVE VALUE OF SOME BLOOD SUBSTITUTES USED FOR TREATMENT OF EXPERIMENTAL SHOCK

CHARLES C. SCOTT, M.D., PH.D., AND HAROLD M. WORTH, A.B.
INDIANAPOLIS
AND
LIEUTENANT E. BROWN ROBBINS, U.S.N.R.

In shock resulting from hemorrhage, trauma or burns, therapy with intravenous injection of fluid is well established as decidedly beneficial. Numerous investigations deal with the value of blood and various blood substitutes in shock. This is partly owing to the desire to find a blood substitute which is highly efficient, readily available, relatively inexpensive and completely safe. Plasma or serum fulfils all requirements except that it is costly. In addition, to bring it to a readily available form, a vast amount of work is required. The great value of plasma outweighs these objections during emergencies such as the present war. In peacetime, these difficulties have considerable practical importance.

Although the use of blood substitutes in the treatment of shock has been widely studied, the results have often been conflicting. In such circumstances, further work is indicated, with attempts to control or standardize procedures more effectively. The present report is concerned with a comparison of results obtained with a number of well known blood substitutes tested in a relatively pure form of traumatic shock.

METHOD

Although our procedure for applying venous tourniquets was published previously,[1] the method may be reviewed briefly. Dogs weighing 12 Kg. or more were used. They were kept in air-conditioned quarters for at least one week prior to their use. The procedure and recovery took place under the same environmental conditions. Free access to water was allowed the animals preceding and following the experiment. The dogs were usually starved for at least eighteen hours before the tourniquets were applied. A dose of 25 mg. per kilogram of seconal sodium (sodium 5-allyl-5(1 methylbutyl) barbiturate) was given intraperitoneally for anesthesia. Thereafter, throughout the period of application of the tourniquets, one-tenth the anesthetic dose was injected intraperitoneally as necessary to maintain light anesthesia. This resulted in no deaths from the anesthetic, which agrees with the observations of Mylon and his associates[2] for pentobarbital. Mean blood pressure was recorded in the carotid artery by cannula and mercury manometer, clean but not entirely aseptic technic being used. Then a pneumatic venous tourniquet was wrapped snugly around each thigh just below Poupart's ligament. The tourniquets were inflated to equal the mean pressure in the carotid artery. Subsequently, whenever the blood pressure changed the tourniquet pressure was readjusted. Thus, they never became arterial tourniquets. When a shock index[3] of 120 was attained, the tourniquets were removed. All untreated animals died. The dogs apparently were all at the same level of shock at the time the tourniquets were removed. Furthermore, this appeared to be relatively early shock. A group of 103 dogs was carried to this level. In an additional series of 21 animals, a shock index of 180 was used. This was a more severe degree of shock than the former.

Following release of the tourniquets, infusion of a blood substitute into the femoral veins was started immediately. The volume administered was the amount calculated to cause the blood volume to return to the original value. This was determined with hematocrits just prior to application of the tourniquets and again when they were removed. On a basis of body weight, however, the various groups of animals all received approximately the same volume of fluid. The blood substitute was infused at a moderate speed—thirty to sixty minutes being required to complete the infusion. The carotid artery was then ligated, the cannula removed, and the wound in the neck sutured. If the animal survived for forty-eight hours, it was considered to have recovered from shock. Most of the dogs which lived for two days made complete recoveries, although a few animals died from such secondary causes as infection.

The blood substitutes tested were dog plasma, isotonic saline solution and solutions of gelatin, pectin and polyvinyl alcohol. In the citrate series, fresh plasma from individual dogs was given to one-half

From the Lilly Research Laboratories, Eli Lilly and Company, Indianapolis.

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1. Scott, C. C., and Robbins, E. B.: Production of Experimental Shock in Dogs by the Use of Venous Tourniquets, J. Indiana M. A. **36**:194 (April) 1943.

2. Mylon, E.; Winternitz, M. C., and de Sütö-Nagy, G. J.: Studies on Therapy in Traumatic Shock, Am. J. Physiol. **139**:313 (June) 1943.

3. Shock index $= \frac{\text{Blood pressure fall (\%)} \times \text{Duration of tourniquet application (minutes)}}{\text{Mean blood pressure at time of removal of tourniquets (mm. Hg)}}$

the group, while the remainder received plasma pooled from 10 animals. Heparinized plasma was also unpooled, but freshly prepared. Gelatin U. S. P. was used as a 7 per cent solution in 0.75 per cent sodium chloride and 0.25 per cent sodium bicarbonate. Pure citrus pectin N. F. in 3 per cent concentration in isotonic saline solution was autoclaved according to the procedure of Bryant, Palmer and Joseph.[4] Polyvinyl alcohol was dissolved in Ringer-Locke solution, concentrations of both 3 and 6 per cent being tested. This solution was sterilized by passage through a Seitz filter. The polyvinyl alcohol was obtained from Dr. N. W. Roome, of Toronto, Canada, who had used it with success in treatment of hemorrhage in dogs. Except for pectin and polyvinyl alcohol, the solutions were not prepared with sterile technic. It is common experience that dogs withstand intravenous infusions of clean but unsterile solutions without development of septicemia.

RESULTS

A total of 124 dogs was tested, 15 of which received no treatment to serve as controls. These 15 animals died. The effects with the various blood substitutes in early shock are shown in table 1. It was readily apparent that the results were the same with citrated plasma, heparinized plasma, isotonic saline solution, gelatin, and 6 per cent polyvinyl alcohol. In our experiments, unpooled citrated plasma caused recovery of 5 of the 10 dogs treated. Six of 10 animals survived following treatment with pooled citrated plasma. Consequently, the latter proved no better in this small series. Heparinized plasma was not more effective than the citrated, in contrast to the work of Ivy and others.[5] This was probably owing to difference of infusion rates. In our experiments, citrated plasma was given slowly enough to allow the citrate to be metabolized and prevent death from calcium deficiency.[6] Two dogs died while receiving plasma and before completion of the infusions. One animal received heparinized plasma, while citrated pooled plasma was given to the other dog. The results in these 2 animals were excluded. In all other animals, a well sustained elevation of blood pressure to approximately normal level occurred in response to plasma, and no abnormal reactions were observed.

TABLE 1.—*Comparative Effectiveness of Blood Substitutes in Early Stage of Shock in Dogs*

Blood Substitute	Total Number of Dogs	Number Lived	Number Died	Average Volume Transfused, Cc. per Kg.
None	15	0	15	0
Citrated dog plasma	20	11	9	25.7
Isotonic solution of sodium chloride	20	10	10	24.3
Heparinized dog plasma	10	6	4	23.1
Gelatin, 7%	10	5	5	23.2
Pectin, 3%	10	7	3	23.6
Polyvinyl alcohol, 3%	10	3	7	25.7
Polyvinyl alcohol, 6%	8	4	4	24.4
Chi square = 3.626			P = 71%	

TABLE 2.—*Comparison of Effectiveness of Plasma and of Saline Solution in Later Stage of Shock in Dogs*

Blood Substitute	Total Number of Dogs	Number Lived	Number Died	Average Volume Infused, Cc. per Kg.
Citrated dog plasma	10	3	7	26.7
Isotonic solution of sodium chloride	11	3	8	25.2

While there was an apparent difference between the effect of 3 per cent pectin and that of 3 per cent polyvinyl alcohol, statistical analysis showed that this difference was not significant. Consequently, under our conditions of experimentation, all solutions appeared to be equally effective. Furthermore, at this level of shock, the dogs had approximately a 50 per cent chance for recovery regardless of what blood substitute was used. Since the reactions to the solutions were similar, it was interesting to note that the only properties which all solutions had in common were the volume of water and the amount of salt they contained. The colloidal material did not increase the therapeutic value of the blood substitute.

The question naturally arose as to whether plasma might prove more effective than saline solution at deeper levels of shock. The series of animals carried to a shock index of 180 provided at least a partial answer. Of 11 dogs treated with saline solution, 3 recovered completely, while 3 of 10 animals given citrated dog plasma lived. As shown in table 2, again there was no demonstrable difference in the therapeutic value of these two blood substitutes.

COMMENT

These results are opposed to those of most investigators who have tested blood substitutes

4. Bryant, E. F.; Palmer, G. H., and Joseph, G. H.: Nonaccumulation of Pectin Intravenously Injected into Rabbits, Proc. Soc. Exper. Biol. & Med. **49**:279 (Feb.) 1942.

5. Ivy, A. C.; Greengard, H.; Stein, I. F., Jr.; Grodins, F. S., and Dutton, D. F.: The Effect of Various Blood Substitutes in Resuscitation After an Otherwise Fatal Hemorrhage, Surg., Gynec. & Obst. **76**:85 (Jan.) 1943.

6. (*a*) Sabbatani, L.: Action antagoniste entre le citrate trisodique et le calcium, Arch. ital. de biol. **36**:416, 1901-1902. (*b*) Muirhead, E. E.; Kregel, L. A., and Hill, J. M.: Freezing Shock: Concentrated Plasma and Serum Therapy With and Without Amputation of the Damaged Extremity, Arch. Surg. **47**:258 (Sept.) 1943. (*c*) Bruneau, J., and Graham, E. A.: A Caution Against Too Liberal Use of Citrated Blood in Transfusions, ibid. **47**:319 (Oct.) 1943.

in treatment of shock. A review of the literature is not the purpose of this work. Furthermore, the excellent reviews of the subject by Scudder,[7] Harkins,[8] Mudd and Thalhimer[9] and Moon[10] are more than adequate. The evidence is practically overwhelming that plasma is more effective than saline solution in treating either acute hemorrhage or posthemorrhagic shock. In traumatic shock, particularly that type in which the fluid lost from the circulation is mainly pure plasma, comparisons of efficiency of blood substitutes have not yielded cleancut results in most instances. The experimental procedures used by most workers to produce shock have usually caused death of all animals regardless of what blood substitute was given. The comparison of therapeutic value has then rested on which blood substitute would maintain an elevation of the blood pressure for a longer period. However, this did not necessarily prove that one solution was more effective than another. In terminal stages of tourniquet shock in rats, Allen[11] demonstrated that plasma or whole blood, but not saline solution, would revive the animals, although death subsequently resulted from shock. In certain earlier stages of shock, saline solution saved the lives of rats when plasma or whole blood failed. Until further knowledge is gained about shock, it appears to us that the one best criterion of therapeutic effectiveness is prevention of death.

One strong argument against the use of isotonic saline solution is the fact that it leaves the circulation rapidly and tends to wash some of the plasma proteins along with it, as reported by Beard, Blalock and others.[12] Isotonic saline solution increases the blood volume for only a short period even in normal animals. Consequently, if restoration of circulating blood volume is the prime factor in treating shock, the effect of saline solution would be only evanescent. However, Rosenthal,[13] using mice, recently showed that saline solution was more effective than serum in treating shock from both burns and tourniquets. Furthermore, the therapeutic value of serum was not changed following removal of all its proteins. The entire theory of treatment of shock by colloidal solutions has been questioned by Allen,[14] who, in various types of shock, infused such large volumes of saline solution (one-fourth to one-half the body weight) that marked generalized edema occurred. Recovery from otherwise fatal shock was effected in these dogs. Katz, Friedberg and Asher[15] likewise have obtained excellent results with saline solution in early treatment of shock caused by venous occlusion of the hindlegs of dogs. These findings tend to cast doubt on the concept that the fluid administered must stay in the blood vessels if it is to be effective in treating all types of shock.

The comparison of our results with those of others is obviously difficult because of difference of experimental conditions. In addition, there is no intention to infer that similar results would hold true in therapy of traumatic shock in human beings. Clinicians generally seem well agreed that plasma is more effective than saline solution in all kinds of shock. It is interesting to note, however, the decidedly beneficial results

7. Scudder, J.: Shock: Blood Studies as a Guide to Therapy, Philadelphia, J. B. Lippincott Company, 1940.

8. Harkins, H. N.: Recent Advances in the Study and Management of Traumatic Shock, Surgery **9**:231 (Feb.); 447 (March); 607 (April) 1941.

9. Mudd, S., and Thalhimer, W.: Blood Substitutes and Blood Transfusion, Springfield, Ill., Charles C Thomas, Publisher, 1942.

10. Moon V. H.: Shock: Its Dynamics, Occurrence and Management, Philadelphia, Lea & Febiger, 1942.

11. Allen, F. M.: Physical and Toxic Factors in Shock, Arch. Surg. **38**:155 (Jan.) 1939.

12. (*a*) Beard, J. W., and Blalock, A.: Intravenous Injections: A Study of the Composition of the Blood During Continuous Trauma to the Intestines When No Fluid Is Injected and When Fluid Is Injected Continuously, J. Clin. Investigation **11**:249 (March) 1932. (*b*) Blalock, A.; Beard, J. W., and Thuss, C.: Intravenous Injections: A Study of the Effects on the Composition of the Blood of the Injection of Various Fluids into Dogs with Normal and with Low Blood Pressures, ibid. **11**:267 (March) 1932. (*c*) Beard, J. W.; Wilson, H.; Weinstein, B. M., and Blalock, A.: A Study of the Effects of Hemorrhage, Trauma, Histamine and Spinal Anesthesia on the Composition of the Blood When No Fluids Are Injected and When Fluids Are Introduced Intravenously, ibid. **11**:291 (March) 1932. (*d*) Blalock, A., and Beard, J. W.: The Effects on the Composition of the Blood of the Subcutaneous Injection of Normal Salt Solution into Normal Dogs and into Dogs Subjected to Intestinal Trauma, Graded Hemorrhages and Histamine Injection, ibid. **11**:311 (March) 1932. (*e*) Beard, J. W.; Wilson, H., and Blalock, A.: Effects on Composition of Blood of Physiologic Solution of Sodium Chloride When Introduced by Intraperitoneal Injection and by Stomach Tube in the Presence of Low Blood Pressure, Arch. Surg. **26**:122 (Jan.) 1933.

13. Rosenthal, S. M.: (*a*) Experimental Chemotherapy of Burns and Shock: III. Effects of Systemic Therapy on Early Mortality, Pub. Health Rep. **58**:513 (March 26) 1943; (*b*) IV. Production of Traumatic Shock in Mice, ibid. **58**:1429 (Sept. 24) 1943; (*c*) V. Therapy with Mouse Serum and Sodium Salts, ibid. **58**:1432 (Sept. 24) 1943.

14. Allen, F. M.: Theory and Therapy of Shock: Varied Fluid Injections, Am. J. Surg. **62**:80 (Oct.) 1943.

15. Katz, L. N.; Friedberg, L., and Asher, R.: Efficacy of Isotonic Sodium Chloride and Glucose Solutions in Preventing Shock Following Venous Occlusion of a Limb in the Dog, Am. J. Physiol. **140**:65 (Oct.) 1943.

of isotonic sodium lactate used orally to treat 35 severely burned patients (Fox [16]). Furthermore, recent investigations tend to agree that iso-osmotic serum is more effective therapeutically than concentrated serum in shock from both burns [13] and hemorrhage.[17] On theoretic grounds, concentrated serum should be at least as efficient because of its greater colloidal content. However, this raises the question of how much water may be safely removed from the extracellular and intracellular fluid. MacFee and Baldridge [18] believed that dehydration was an extremely influential factor contributing to shock. They recommended large volumes of saline solution for treating shock and condemned acacia on the basis that it holds water in the blood vessels. Warren, Merrill and Stead,[19] in a recent study, showed that the quantity and pressure of the extracellular fluid were important in determining the size of the plasma volume. A marked decrease in plasma protein was compensated by a marked increase of extracellular fluid pressure.

16. Rosenthal,[13c] p. 1435.

17. (*a*) Levinson, S. O.; Weston, R. E.; Janota, M., and Necheles, H.: The Effects of Concentrated Serum in Contrast to Iso-Osmotic Plasma upon Normal and Dehydrated Dogs in Shock, Surgery **12**:878 (Dec.) 1942. (*b*) Necheles, H.; Levinson, S. O.; Janota, M.; Weston, R. E., and Weissman, V.: Studies on the Therapy of Hemorrhagic Shock: I. The Effects of Iso-Osmotic and Concentrated Serum and Plasma in Normal Dogs, Surg., Gynec. & Obst. **77**:337 (Oct.) 1943. (*c*) Levinson, S. O.; Janota, M.; Weston, R. E., and Necheles, H.: Studies on the Therapy of Hemorrhagic Shock: II. The Effects of Iso-Osmotic and of Concentrated Serum and Plasma in Dehydrated Dogs, ibid. **77**:475 (Nov.) 1943.

18. MacFee, W. F., and Baldridge, R. R.: (*a*) Post-Operative Shock and Shock-Like Conditions: Treatment by Infusion in Large Volume, Ann. Surg. **91**:329 (March) 1930; (*b*) Physiological Considerations Related to the Infusion Treatment of Shock, ibid. **100**: 266 (Aug.) 1934.

19. Warren, J. V.; Merrill, A. J., and Stead, E. A., Jr.: The Role of the Extracellular Fluid in the Maintenance of a Normal Plasma Volume, J. Clin. Investigation **22**:635 (Sept.) 1943.

The exact action of isotonic saline solution in combating shock in our experiments was not determined. There has been some speculation by authors recently, based on known actions of sodium chloride. Rosenthal [13] demonstrated conclusively in his animals that the therapeutic action was due entirely to the sodium ion. In addition, the efficiency of sodium was decreased or neutralized by potassium. Other possibilities exist such as the dilator action of sodium chloride on blood vessels.[20] However, no proof of the exact mode of action of isotonic solution in shock has yet been presented.

SUMMARY

The comparative therapeutic values of a number of blood substitutes were studied in venous tourniquet shock of dogs. The procedure was controllable, so that each animal was carried to a predetermined level of shock before therapy was instituted. One series of animals was studied in early shock and a second series in shock of more severe degree. Untreated animals always died. The blood substitutes tested were citrated dog plasma; heparinized dog plasma; saline solutions of gelatin, pectin and polyvinyl alcohol; and isotonic saline solution. All of these solutions were tested in early shock. In the more severe shock, citrated dog plasma and isotonic saline solutions alone were compared. In both series, no difference in effectiveness could be demonstrated between any of these solutions. It appeared that in this type of shock water or sodium chloride or a combination of the two was the effective therapeutic agent, while the colloidal substances did not add to or detract from the value of these blood substitutes. Since this investigation was limited to shock resulting from venous tourniquets in dogs, we do not imply that saline solution would be as effective in treating other varieties of shock in animals or in man.

20. Katz, L. N., and Lindner, E.: The Action of Excess Na, Ca and K on the Coronary Vessels, Am. J. Physiol. **124**:155 (Oct.) 1938.

GIANT NEVUS OF THE THIGH SUCCESSFULLY TREATED BY COMPLETE EXCISION AND PRIMARY GRAFTING

KENNETH L. PICKRELL, M.D., AND RICHARD C. CLAY, M.D.*
BALTIMORE

Giant moles or nevi, while not a medical rarity, are uncommon. While there is hardly any one who does not have several moles on his body, those few unfortunate persons who have large areas of cutaneous surface occupied by enormous disfiguring nevi live under a real cosmetic handicap. That such cases are not exceedingly rare is evidenced by the rather voluminous literature dealing with them. The majority, however, are reported as medical curiosities since treatment has usually been beyond the scope of ordinary means. As far as we are aware, the mole in the present case is the largest that has ever been excised and the defect closed by grafts, in either single or multiple stages.

Admittedly the various giant nevi reported in the literature have not been histologically uniform. Pack and Sunderland [1] described 4 personal and 156 bibliographic cases of what they termed nevus unius lateris, the criteria for which were verrucous or papillary form, linear configuration, unilaterality and extensiveness. These had been assigned thirty-nine different names in the literature. The authors did not agree with the frequently stated theory that the lesions followed the distribution of cutaneous nerves or blood vessels. Microscopically they found that the lesions showed hyperkeratosis, distortion of epidermis and elongation of papillae. "Nevus cells are seldom, if ever, seen." As evidence that the lesions are epithelial, they pointed out that when malignancy develops in such areas it is basal cell or squamous in type.

Conway [2] described 2 personal and 38 bibliographic cases of bathing trunk nevus. Reuben [3] had previously recorded 32 such cases, including 1 of his own. Conway pointed out that these lesions, which roughly cover the lower part of the trunk and upper part of the thighs and have a brown, hairy, verrucous appearance, occasionally give rise to melanosarcoma. As early as 1912 Fox [4] was able to find reports of 25 of these nevi with bathing trunk distribution on the occasion of reporting a personal case. There is a good deal of overlapping in the cases reported.

Quigley [5] reported an interesting case of bathing trunk nevus extending to the angles of the scapulas and almost half the length of the thighs. Fishback's [6] patient had a mole which covered the back and flanks, and he died of malignant melanoma with multiple metastases. In Bhatavadeker's [7] case the patient had a mole covering the posterior part of the neck, the interscapular region, scapula and axilla. Numerous other cases of giant moles have been described.

Fig. 1.—Position and extent of the nerve nevus. Beginning in the fold of the buttock, it extends medially to involve the left side of the perineum, laterally and superiorly to the uppermost part of the thigh, and inferiorly to the lower leg.

TREATMENT

Many kinds of treatment of these disfiguring lesions have been suggested. They have been

* Harvey Cushing Fellow in Surgery.
From the Department of Surgery, the Johns Hopkins Hospital and University.

1. Pack, G. T., and Sunderland, D. A.: Nevus Unius Lateris, Arch. Surg. **43**:341 (Sept.) 1941.

2. Conway, H.: Bathing Trunk Nevus, Surgery **6**:585, 1939.

3. Reuben, M. S.: Nevus Pigmentosus Pilosus, Arch. Pediat. **45**:364, 1928.

4. Fox, H.: A Case of Extensive Pigmented and Hairy Nevus, J. A. M. A. **58**:1190 (April 20) 1912.

5. Quigley, D. T.: A Case of Enormous Pigmented Mole, J. A. M. A. **82**:2029 (June 21) 1924.

6. Fishback, H. R.: Giant Pigmented Nevus with Malignant Transformation, Am. J. Cancer **40**:471, 1940.

7. Bhatavadeker, D. M.: An Interesting Case of Nevus, Indian M. Gaz. **60**:479, 1925.

attacked with corrosives like nitric acid and phenol, with radium and the roentgen rays, by electrodesiccation, by arsenicals, with solid carbon dioxide and by simple curettage. The results have been variable, usually unsatisfactory and sometimes disastrous. As Reid [8] pointed out, moles should either be completely exised or let alone. Unfortunately, relatively few of the lesions under consideration here have been amenable to excision, the obvious difficulty being the closure of the extensive defect left by excision of so much integument.

Roy [9] treated a 19 year old girl who had a nevus of the right cheek, upper lip and nose by multiple stage elliptic excisions with primary closure until maximal tolerable tension of the skin was attained, and he followed this by a further excision from the cheek, and covered the defect with a "dermatoepidermic" graft from the arm. He later applied a Thiersch graft to the defect remaining after the final excision of the portion on the lip. Ultimately the nevus was excised from the nose and a single pedicle flap

Fig. 2.—A close-up view of the nevus shows the many cracks and fissures, also the long hairs growing from the upper part. The nevus measured more than 18 inches in length and 10 inches in width.

8. Reid, M. R.: Treatment of Pigmented Moles, Internat. Clin. **4**:222, 1933.

9. Roy, J. N.: A Case of Pigmented Nevus of the Nose with Pigmented, Hairy, and Warty Nevus of the Cheek and Lip; Multiple Autoplasty; Cure, Canad. M. A. J. **15**:138, 1925.

from the arm was used to cover the defect. The cosmetic result was good.

Meyer [10] excised a large mole covering half the scalp and measuring 20 by 8 by 15 cm. and successfully closed the defect with a Thiersch graft from the thigh. Figi [11] was able to remove a large thick "neuromole," 25 by 22.5 by 4 cm., from the left temporal, parietal and occipital regions of a 29 year old man. He chose to close the defect with two large full thickness grafts from the abdomen and thigh in order to preserve hair follicles. The result was good.

Pack and Sunderland [1] found 2 of their 4 cases amenable to surgical procedures. The first patient was a white girl of 13 years who had a spotty, verrucous, pigmented mole covering part of the left breast, abdomen, thigh, axilla, arm and hand. First, an intramammary tumor was excised after preliminary roentgen treatment, and later the abdominal portion was excised and the defect covered with Thiersch and Reverdin grafts. A year later the portions over the chest and flank were excised by multiple elliptic excisions with primary closure. The remainder of the lesion was intermittently treated with roentgen rays. Nine years later the patient died of carcinoma of the involved breast following radical mastectomy.

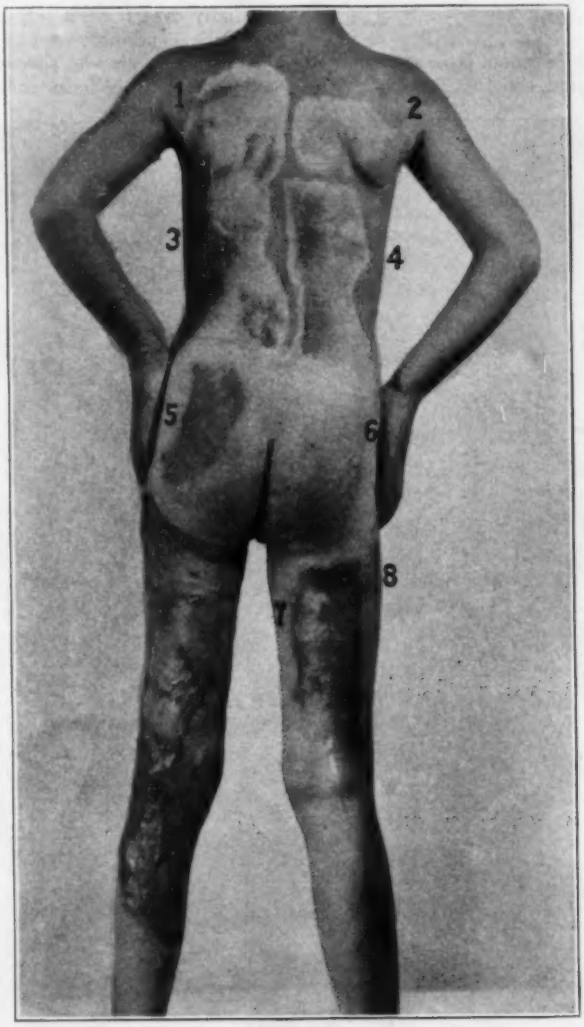

Fig. 3.—Postoperative photographs showing the various areas (designated by numbers) from which split thickness grafts were cut with the Padgett dermatome. Eight "drums" of skin were required to cover the defect, which measured 220 square inches.

The other patient was a 39 year old white man who had a papillary pigmented nevus of parts of his chest and one axilla and arm. Three excisions with primary closure were carried out; two excisions were followed by Reverdin grafts,

10. Meyer, H. W.: Massive Congenital Fibromatosed Pigmented Mole of Scalp, Surgery **1**:616, 1937.

11. Figi, F. A.: Extensive Mole of the Face and Scalp: Excision and Full Thickness Skin Graft, Proc. Staff Meet., Mayo Clin. **16**:280, 1941.

and one by a Thiersch graft. The lesion was completely removed, but the patient died three years later of an apparently unrelated epidermoid carcinoma of the esophagus.

We report a case in which an enormous, pigmented, hair-bearing "nerve nevus" was completely excised from the lower extremity of a child and the defect successfully covered by split-thickness grafts (figs. 1 and 2).

History.—A 6 year old white school boy was admitted to the Johns Hopkins Hospital on Aug. 10, 1943. The child's father is said to have had a pigmented hairy nevus of the buttock, but there was no other familial or hereditary trait. At birth a rough, hairy nevus was seen to occupy most of the medial, lateral and posterior surfaces of the left thigh and upper part of the left lower leg. The lesion grew and increased in size with the child's normal growth and development, and although its borders remained unchanged, it grew noticeably in thickness, reaching almost an inch (2.5 cm.) in height above the surrounding skin. On numerous occasions deep cracks or fissures developed which bled profusely and were prone to ulceration and infection. At other times, because of trauma at play or from the rubbing of his clothing, large horny projections would be rubbed off. Except at these times, the lesion caused no discomfort. Because of the frequent episodes of trauma, bleeding and ulceration, the child was brought to the hospital.

Examination.—Physical examination showed a well developed boy of 6 years weighing 56 pounds (25.4 Kg.) and measuring 58 inches (147.3 cm.) in height. Examination revealed no abnormality except the specific lesion. Beginning at the fold of the left buttock and extending medially over the left side of the perineum and laterally over the uppermost part of the thigh, the greater part of the left thigh was covered by a horny, black, raised, hairy nevus which extended inferiorly as far as the middle of the lower leg. The lesion measured 19 inches (48.26 cm.) in length and 10 inches (25.4 cm.) in width. Numerous long black hairs grew from different parts of this nevus and from its circumference. Many small cracks or fissures were present which were secondarily infected, and the lesion had a "foxy" odor. Directly over the sternum there was a flat, slightly pigmented mole the size of a half dollar.

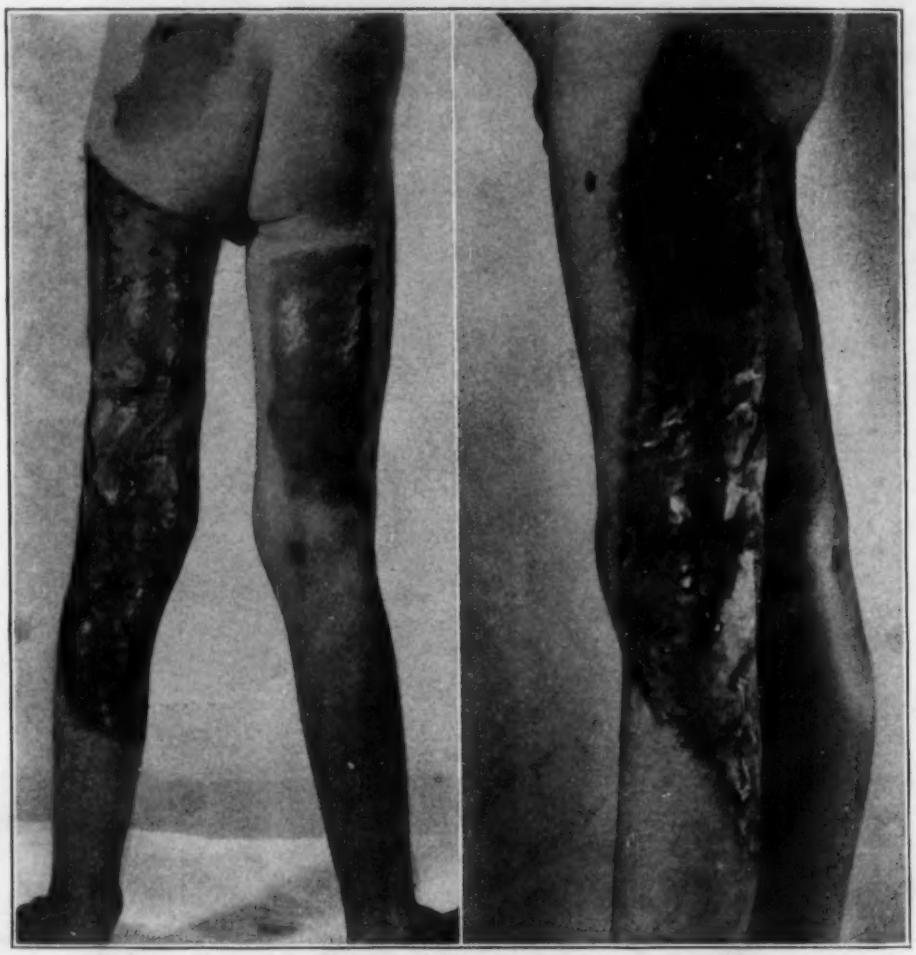

Fig. 4.—Close-up view of the grafted area six weeks after operation. Function of the extremity was normal. Note the reduction in size of the leg and thigh following the removal of the nevus.

Operation.—On August 11, with the patient under ether anesthesia, the nevus was excised and grafts applied in one sitting. The mass was excised in toto with more than a half inch (1 cm.) margin. The nevus

extended into the subcutaneous tissues but did not invade the fascia or muscle. The size of the defect resulting from the excision was 20 inches in length (50.8 cm.) and 11 inches (27.94 cm.) in width, a total area of 220 square inches (1,419.4 sq. cm.).

The entire posterior surface of the body had been prepared with ether, alcohol and potassium mercuric iodide, and 8 sheets of heavy split thickness skin were cut from this donor area with the Padgett dermatome (fig. 3). The sheets of skin were placed on the defect in a "patchwork" manner, and were sutured to one another and to the periphery. The grafts were scored in many areas to allow the escape of serum and blood. Small pieces of excess skin were replaced on the donor sites to hasten epithelization. A single layer of sulfadiazine film[12] was placed directly over the donor and recipient areas, and snug pressure dressings were applied.

Postoperative Course.—The original dressings were not changed until the tenth postoperative day, at which time all of the grafts appeared to be viable. There was no gross infection. The donor areas were healing rapidly. The donor and recipient areas were dressed with gauze impregnated with sulfadiazine, and pressure dressings were applied. When the dressings were changed on the twenty-first postoperative day it was apparent that a few small areas in the donor site would require grafting; therefore on September 9, about twenty small deep Davis grafts were taken from the interscapular region and applied to the small unhealed donor areas on the posterior surface of the trunk. These healed promptly, and the child was ready for discharge six weeks after operation (discharge photograph, fig. 4).

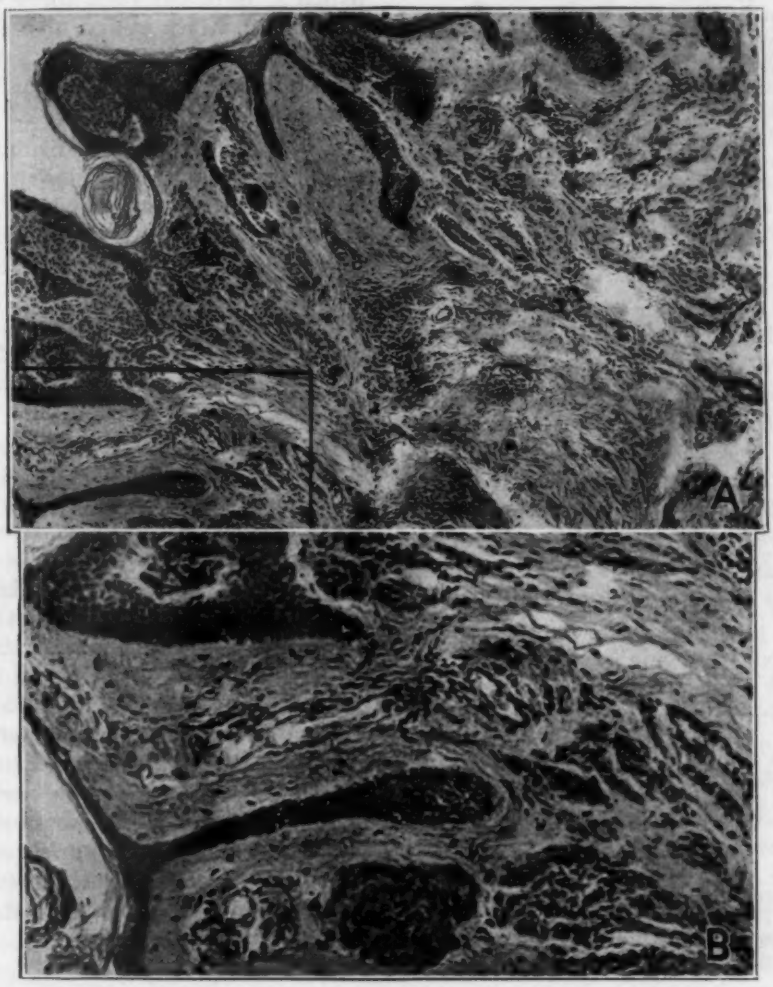

Fig. 5.—*A*, microscopic section of mole, low magnification, showing mole cells dispersed through dermis and grouped in nests. Keratinized layer of epithelium is represented by amorphous mass in surface crevice. *B*, higher magnification of *A*, showing the arrangement of the mole cells suggesting Meissner's corpuscles.

Pathologic Report.—The specimen as received in the laboratory contained a large, hairy mole measuring about 19 inches in length and 10 inches in width. It had been shrunken by fixation and rolled under at the edges. Almost the entire area of the specimen was occupied by the gigantic mole, a narrow cuff of normal skin surrounding it. The surface of the mole was fissured and rough and bore numerous rather coarse hairs. The rough material on the surface was so friable that particles of it came off easily when the specimen

12. Pickrell, K. L.: A Sulfanilamide Film for Use as a Surgical Dressing, Bull. Johns Hopkins Hosp. **71**:304, 1942.

was handled. The thickness of the excised tissue averaged 2 cm., and the under surface showed grossly normal subcutaneous tissue.

Microscopically, the most striking feature was the thick, superficial layer of amorphous material corresponding to the friable layer of the gross specimen. Beneath this there was an intact thin layer of squamous epithelium whose basal layer, especially, contained brown, granular melanin pigment. The entire epithelial surface was thrown up into tall, irregular, papillary projections. The dermis was rather loose in texture with a fibrillary appearance and contained both hair follicles and sweat glands. Distributed throughout the dermis were numerous mole cells which in the deeper layers were loosely scattered and in places aggregated to resemble Meissner's corpuscles. The mole cells were more compactly arranged in dense nests between the epithelial papillae and here contained some brown melanin. There was no suggestion of malignancy or invasiveness of either the epithelium or the mole cells.

The pathologic diagnosis was benign pigmented melanoma of nerve-nevus type. Photomicrographs of the specimen at high and low power appear in figure 5.

COMMENT

A review of the literature shows that most nevi either are present at birth or appear during the first year of life. They usually increase in size with the growth and development of the child. Of the reported cases, all occurred in the white race with two exceptions, one in a Filipino [13] and one in a Negro.[14] Most authorities do not believe that heredity is a prominent factor, although in our case the patient's father also had a pigmented nevus of the buttock. While many of the nevi in the published cases showed striking pigmentation, on histologic section there was rarely increased pigmentation of the basal epithelial layer. Our case showed moderately large amounts of granular pigmentation in the basal layer. In addition, mole cells were scattered through the dermis and in the deeper layers were compactly arranged in dense nests between the epithelial papillae, as shown in the photomicrograph (fig. 5).

In the reported cases no method of treatment except surgical excision with primary closure or grafting of skin was of lasting benefit. Lesions of the trunk were most frequently transverse and those of the extremities longitudinal. In many patients, as in our own, there was a segmental distribution which at first glance seemed to coincide with nerve distribution; but on close examination in the reported cases this relationship was not always observed.

The occurrence of other malformations such as those of the skeletal or muscular systems, especially the association of epilepsy, has been interpreted by some authors as showing the relationship of nevi to the central nervous system. Although various congenital abnormalities seem to appear more frequently in persons having a nevus than in those not having one, the possibility of mere coincidence cannot be discarded.

SUMMARY

The majority of giant nevi reported in the literature are described as medical curiosities since treatment has usually been beyond the scope of ordinary means. As far as we are aware, this is the largest nevus that has been excised and the defect closed by grafting in either single or multiple stages. The patient was a 6 year old white boy with a nevus of the lower extremity measuring 19 inches in length and 10 inches in width. Excision of the nevus left a defect which measured 220 square inches. Immediately after excision it was successfully covered with eight sheets of heavy split thickness skin which were cut from the posterior surface of the trunk, a Badgett dermatome being used. The grafts healed by first intention, and the child was ready for discharge in six weeks.

13. Hasselmann, C. M.: Naevus Pigmentosus Verrucosus Unilateralis Zosteriformis: The First Case in a Filipino, Jap. J. Dermat. & Urol. **35**:63, 1934; abstracted, Arch. Dermat. & Syph. **31**:398 (March) 1935.

14. Lindenheim, H.: Zur Kenntnis der systematisierten Naevi, Dermat. Ztschr. **24**:144, 1917.

A REVIEW OF UROLOGIC SURGERY

ALBERT J. SCHOLL, M.D.
LOS ANGELES
FRANK HINMAN, M.D.
SAN FRANCISCO
ALEXANDER VON LICHTENBERG, M.D.
MEXICO, MEXICO
ALEXANDER B. HEPLER, M.D.
SEATTLE
ROBERT GUTIERREZ, M.D.
NEW YORK
GERSHOM J. THOMPSON, M.D.
ROCHESTER, MINN.
EDWARD N. COOK, M.D.
ROCHESTER, MINN.
EGON WILDBOLZ, M.D.
BERNE, SWITZERLAND
AND
VINCENT J. O'CONOR, M.D.
CHICAGO

KIDNEYS

Renal Ectopia.—Rusche and Bray [1] state that prior to the introduction of urography renal ectopia was rarely diagnosed clinically and that in most of the reported cases the condition was discovered either at the time of operation or at necropsy. The symptoms are not purely renal but frequently simulate pelvic or intra-abdominal disease. Modern urologic methods, however, have simplified this diagnostic problem, although a common pitfall is the assumption that a composition of the urine within normal limits indicates a sound urinary tract. Certain cases of renal malposition present a strong argument against this misconception and drive home the need for urologic study in cases of obscure pelvic and abdominal symptoms.

There is no definite group of symptoms peculiar to renal ectopia. An ectopic kidney is subject to all the morbid changes which may beset its normal counterpart and is rendered even more vulnerable than a normal kidney as a consequence of its position. This is explained on the basis of impaired drainage and possible trophic defects due to its aberrant blood supply. Symptoms may appear as the result of renal pathologic changes or of pressure from crowded contiguous structures. Such symptoms often lead to a confused interpretation and a mistaken diagnosis of some pelvic or intra-abdominal condition or retroperitoneal neoplasm. On the other hand, an ectopic kidney may not produce any symptoms, and the patient may live a normal life span without being aware of his condition.

Diagnosis is not difficult with the aid of urography, and information obtained by this means is more complete from a retrograde study than from the intravenous urogram. An ectopic kidney may lie anywhere between the third lumbar vertebra and the hollow of the sacrum; in rare cases it has been found in the thoracic cavity; it has also been known to herniate through the inguinal canal. As a rule it is smaller than average, it may be smooth or lobulated, and its shape is influenced by the surrounding structures.

Two main types of renal ectopia exist: simple and crossed, which in turn may appear in unilateral or bilateral arrangement. Simple unilateral malposition is the commonest form. In crossed ectopia the anomalous organ lies on the same side as, and below the level of, the normal kidney, and its ureter empties into the opposite side of the bladder. There is little difficulty in distinguishing between the ptosed and the ectopic kidney, since the latter is fixed in position because of a short ureter, manifests an aberrant blood supply composed of short trunks and lacks the fatty capsule. The ptosed kidney is usually freely movable if it is not bound in position by adhesions, and it always has a ureter approximating normal length. Opaque catheters in place will reveal the length and course of the ureters on roentgenologic examination.

The symptomless ectopic kidney should be left alone. If symptoms warrant, and if the condition

1. Rusche, C. F., and Bray, J. L.: Renal Ectopia: Report of Two Cases, J. Urol. **50**:123-130 (Aug.) 1943.

of the other kidney is good and its function adequate, operative intervention should be undertaken. As the ectopic kidney is fixed in position by adhesions and numerous aberrant vessels, it does not lend itself to plastic surgery, and therefore nephrectomy is the procedure of choice. The transperitoneal route is the surgical approach recommended, because it provides easy access to the kidney, permits ligation of blood vessels as they are encountered and minimizes damage to the large vessels which may lie directly beneath the organ.

Rusche and Bray report 2 cases of unilateral ectopic kidney, giving their clinical history and recording the surgical treatment (transperitoneal nephrectomy) through motion pictures in color.

Daseler and Anson [2] report a case of bilateral renal ectopia in an adult man. The location of the kidneys was iliolumbar, the lower third of each being situated in the iliac fossa.

The right kidney was covered anteriorly by the cecum, the ascending colon and the duodenal flexure; it was crossed by several large branches of the ileocolic artery. The pelvis of the right kidney was rotated medially. Two right renal arteries were present, originating from the aorta at the level of the mesenteric arteries. Three right internal spermatic arteries occurred. Two right renal veins were present, separated by an interval of 2 cm. and draining separately into the inferior vena cava.

The left kidney was normal in size, but its pelvis was situated anteriorly and measured 5 cm. in length (half the total length of the organ). There was a single left renal artery, derived from the aorta. Two left internal spermatic arteries were present. Three renal veins emerged from the left renal hilus to fuse into a single preaortic trunk draining into the inferior vena cava.

In simple structural terms, the kidneys, the ureters and the associated blood vessels (including the aorta and the vena cava) may be said to be contained in, and supported by, a fascial envelope which is interposed between the anteriorly placed vessels (and autonomic nerves) of the digestive tube and the posteriorly situated parietal vessels, the nerves of the lumbar plexus and the lumbar musculature. Whether the kidney is normal or ectopic, the investment remains the same. Within the investing fascia the renal arteries and veins will have connection with the aorta and the vena cava or with pelvic extensions of these by vessels which course in a transverse plane. The anterior and posterior relations to the retroperitoneal vessels in front and to the retrofascial nerves and muscles behind would be predictable within the limits of normal anatomic variation.

Tumor Thrombosis of the Renal Vein.—McDonald and Priestley [3] review data on approximately 700 cases of malignant tumor of the kidney in an effort to determine the surgical and the prognostic significance of tumor thrombosis of the renal vein. Some kidneys that had been mutilated were discarded from the series, which left 636 kidneys containing malignant neoplasms for inclusion in this study. Only that portion of the renal vein and artery with their tributaries which lay outside the renal parenchyma was examined. The presence or the absence of a malignant neoplasm in the aforementioned portion of the renal vein and artery or in the perineural lymphatics situated outside the renal parenchyma was determined, and any neoplasm found was identified, by gross and histologic methods in all cases.

In 509 of the 636 cases the renal cancer was a hypernephroma. Malignant thrombosis of the renal vein was present in 275, or 54 per cent, of the cases of hypernephroma. There was no evidence of neoplastic involvement of an artery in any of the cases of hypernephroma. In a number of instances histologic examination disclosed endarteritis of the main renal artery, occasionally with benign thrombosis, but neoplastic involvement could not be demonstrated. Involvement of the perineural lymphatics was observed in only 1 case.

The mortality rates in the first year after the patients with hypernephroma were dismissed from the hospital were as follows: 38 per cent for those in whom the renal vein was thrombotic at the time of operation and only 18 per cent for those in whom tumor thrombosis of this vein was not present. This is another indication that tumor thrombosis of the renal vein in a case of hypernephroma seriously affects the prognosis. The five year survival rate in these two groups of patients combined was 41.5 per cent. It was 55.4 per cent for those in whom tumor thrombosis of the renal vein was not encountered at operation and only 29 per cent in those in whom thrombosis was present.

A thrombotic renal vein was found in 49.8 per cent of cases in which the hypernephroma was grade 1 or 2 and in 61.9 per cent of those in which the tumor was grade 3 or 4. It is

2. Daseler, E. H., and Anson, B. J.: Anatomical Relations of Ectopic Iliolumbar Kidneys Bilateral in Adult, Unilateral in Fetus, J. Urol. **49**:789-802 (June) 1943.

3. McDonald, J. R., and Priestley, J. T.: Malignant Tumors of the Kidney: Surgical and Prognostic Significance of Tumor Thrombosis of the Renal Vein, Surg., Gynec. & Obst. **77**:295-306 (Sept.) 1943.

apparent, therefore, that even hypernephroma of low grade has a great tendency to invade the renal vein.

The incidence of tumor thrombosis according to the weights of the involved kidneys was as follows: 40.6 per cent for weights of less than 500 Gm., 58.8 per cent for those of 500 to 999 Gm. and 63.1 per cent for those of 1,000 Gm. or more.

In 76, or 11.9 per cent, of the entire series of cases of malignant tumor of the kidney, the neoplasm was a carcinoma of the renal pelvis. Involvement of the perineural lymphatics in the hilus of the kidney or tumor thrombosis of the renal vein or both were present in 34, or 44.7 per cent, of the cases of carcinoma of the renal pelvis. Thrombosis of the main renal vein or of one of its smaller branches in the hilus of the kidney was present in 31 of the 34 cases. Involvement of the perineural lymphatics in the hilus of the kidney was present in 23 of the 34 cases. Tumor thrombosis of the renal vein was present in 20, or 86.9 per cent, of the 23 cases in which there was involvement of the perineural lymphatics. In 1 of the 20 cases thrombosis of the renal artery also was present.

Tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both were present in 14, or 45.2 per cent, of the cases of Wilms's tumor. The perineural lymphatics were involved in 2 cases. Tumor thrombosis of the renal vein also was present in 1 of these cases. Tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both apparently had little influence on the five year survival rate in the cases of Wilms's tumor.

Tumor thrombosis of the renal vein was present in 2 of the 20 cases of sarcoma of the kidney. Involvement of the perineural lymphatics was not encountered in any of these cases. Here thrombosis of the renal vein did not appear to be of prognostic significance.

A renal neoplasm should be handled as gently as possible to avoid breaking loose a possible tumor thrombus in the renal vein. It should not be compressed, pulled on or manipulated in any other manner to more than a minimal degree. As soon as possible during the operation the surgeon should identify and isolate the renal pedicle.

The wall of the vein containing a tumor thrombus may become involved by the neoplastic process. This means that the portion of the vein to which the thrombus is attached must also be removed if all tumor tissue is to be removed.

The easiest type of tumor thrombus to deal with is the one which extends for such a short distance in the renal vein that there is enough uninvolved portion of the vein for the application of clamps between the thrombus and the vena cava. Such a case does not offer any particular problem except that care always should be taken not to dislodge the thrombus and not to include any of it in the clamps. In other cases it may be found that the thrombus extends almost to the vena cava so that there is space for the application of only one clamp between the end of the thrombus and the vena cava. Under these circumstances this clamp should be applied to the renal vein and the tumor removed. Any involved portion of the renal vein distal to the clamp may then be excised, and the remaining portion may be utilized for obtaining hemostasis either by ligature or by suture. If necessary, one or more clamps may be left in place on the renal vein with safety. These are loosened in forty-eight hours and removed in seventy-two hours. Fortunately, the renal artery in cases of hypernephroma is practically never involved with tumor thrombus, and therefore the arterial blood supply to the kidney may be controlled in the usual manner.

Wilms's Tumor.—Livermore [4] presents a case of Wilms's tumor in a woman 37 years of age. In 1941, the right kidney was explored, and a perirenal abscess and a tumor mass were found. Cystoscopic and pyelographic examinations revealed a large mass continuous with the lower pole of the right kidney. This kidney with the mass was removed surgically, and the diagnosis was Wilms's embryonal tumor.

Tuberous Sclerosis.—Mertz [5] reports a case of tuberous sclerosis of the brain and renal tumor. The patient, a girl aged 3, had a congenital enlargement of the left leg and the left side of the vulva. Fulness in the upper part of the abdomen was noted, though no mass or deformity was made out. On the outer aspect of the thigh were numerous small capillary hemangiomatous areas, and the skin in this region had a slightly bluish tinge. A diagnosis of probable hemangioma of the left leg and of the vulva was made. No treatment was instituted. Six years later the patient, aged 9, entered the hospital because of convulsions, swelling of the left leg and of the vulva and presence of a mass in the upper left portion of the abdomen. There

4. Livermore, G. R.: Wilms' Tumor in the Adult: Report of a Case, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:67-71, 1943.

5. Mertz, H. O.: Tuberous Sclerosis and Renal Tumor, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:73-85, 1943.

was a cutaneous eruption over the face. The left leg was approximately one and a half times as large as the right, and a mass the size of a grapefruit was found in the upper left abdominal quadrant. A roentgenogram of the skull revealed multiple irregular areas of calcification in the calvarium or the cortical surface of the brain. A diagnosis of tuberous sclerosis with adenoma sebaceum, renal tumor on the left side and congenital angiomatous changes in the left leg and left labium majus was made. The patient was given sedation treatment for her convulsions and roentgen treatment for her renal neoplasm.

Mertz states that the three most often encountered types of neurocutaneous syndrome that may be accompanied by a renal tumor are Recklinghausen's neurofibromatosis, Bourneville's tuberous sclerosis and Lindau's type of von Hippel's disease, a form of angiomatosis. Each is due to a congenital malformation occurring in the brain, the skin, the heart, the eyes, the kidneys, the bones or occasionally other viscera. The pathologic changes and the clinical expression are distinctive and definite in each disease.

Tuberous sclerosis is a chronic disease which particularly affects the brain, the eyes and the skin but which to a lesser degree involves the mesoderm, resulting in formation of an embryonic tumor in the heart, the kidneys or other viscera. Invasion of the brain results in varying degrees of mental defect and convulsions. The cutaneous lesion, adenoma sebaceum, is present on the cheeks and the nose. It is most characteristic in its butterfly distribution and is usually most evident in the nasolabial folds. The ocular changes consist of flat tumors on the retinas. Typical changes occur in the heart and the kidneys and less frequently in other viscera.

There is no treatment known for tuberous sclerosis. The disease is progressive. It is observed sometimes in adulthood but occurs most often in childhood. Most patients die between the fifth and the fifteenth year of age, and death results most often from cachexia, pulmonary disease or status epilepticus.

The characteristic renal lesion in tuberous sclerosis is a tumor formation. While it was thought at first that the renal changes were accidental and did not have any relation to the lesion of the brain, it was soon suggested that they had more than a casual relation and that the hypertrophic nodular gliosis in the brain and the tumor formation in the kidney were but two expressions of one and the same disease.

Most of those making complete necropsy reports on patients with tuberous sclerosis have noted the presence of renal tumors, yet occasionally an instance of tuberous sclerosis without renal changes has been shown.

The renal changes may be bilateral. The relative frequency of both kidneys being involved is difficult to determine, as reference to the renal lesion in necropsy reports is most often limited and incomplete. In 16 of the 19 cases of renal tumor in the Fowler and Dickson series, both kidneys were affected. In the series of 42 patients with tuberous sclerosis and tumor of the kidney whose records Mertz has collected from the literature, the disease was bilateral in 34 and unilateral in 2.

The characteristic lesion in the kidney is a cystic or a solid tumor. While the two types of tumor may occur independently, in most instances careful study will demonstrate that both types are present. The tumors are primarily cortical in location, and frequently they extend into the medulla, but in doing so there is no invasion of the deeper structures as in cancerous renal tumors. Almost invariably the tumors are multiple, and many definitely distinct tumors are present with no appreciable tendency toward the formation of one large tumor mass.

Hydronephrosis.—Henline and Menning,[6] in discussing hydronephrosis due to ureteropelvic obstruction, state that the diagnosis of ureteropelvic obstruction should be made before operation by a ten minute delayed roentgenogram.

The exact cause of the obstruction must be sought and corrected at the operating table.

Among urologists and roentgenologists the opinion still prevails that aberrant vessels are the primary cause of most ureteropelvic obstructions. In Henline and Menning's cases the most common cause of obstruction was intrinsic stenosis. Stenosis and aberrant vessels frequently coexist, and at operation careful study of the ureteropelvic junction may be required to determine the primary cause of the obstruction. When stenosis and aberrant vessels coexist, both must be corrected to establish adequate drainage.

The success of any plastic operation on the ureteropelvic junction depends as much on prolonged nephrostomy drainage and ureteral splinting as on the surgical procedure employed. A Malecot catheter serves well for prolonged nephrostomy drainage, and a soft rubber catheter

6. Henline, R. B., and Menning, J. H.: Management of Hydronephrosis Due to Ureteropelvic Obstruction: Preliminary Report, J. Urol. **50**:1-24 (July) 1943.

which fits snugly into the ureter has proved to be a satisfactory ureteral splint.

In cases in which this method of prolonged drainage was followed, the immediate results with both Y-plasty and end to end anastomosis have been gratifying.

Cyst.—Braasch [7] states that recently he has observed in a number of patients unusual renal cysts which have been more or less difficult to classify. He refers to cysts situated in the renal cortex adjacent to a calix. These cysts apparently have their origin in the tip of the calix and in many instances should be considered cystic dilatations of the calix. They often start with the formation of a small stone in the tip of the calix which obstructs the tubules leading into it, causing cyst formation. Chronic pyelonephritis may produce constriction of the infundibulum leading to a calix with secondary formation of a cyst. In no sense of the word can these cysts be called simple or solitary renal cysts. The best term to describe them has been offered by Quinby, who suggested the name "pyelogenic cysts." As a rule, they are smaller than the "simple" cysts usually observed. Renal cysts occasionally are observed that were primary cortical or "simple" cysts situated adjacent to the pelvis which ruptured into a calix. It may then be difficult to distinguish them from pyelogenic cysts.

The diagnosis is made possible by urography. As a result of routine employment of this procedure in recent years the lesion is recognized much oftener than formerly. In some cases the cysts are not visualized in the excretory urogram and their presence may be determined only by a retrograde pyelogram. In other cases they are visualized only in the excretory urogram. In some instances the original connection with the pelvis has been sealed off so that for all practical purposes they become cortical cysts. A calculus, usually small, is present in many of these cases. The question may arise whether the stone is a secondary formation rather than a primary etiologic factor. If multiple small stones should be present in the cyst, they would seem to be definitely secondary.

Persistent or recurring urinary infection is usually the predominant clinical evidence in cases of pyelogenic cyst. Hematuria is sometimes observed. Acute pain usually is absent. The accidental discovery of the cysts in the course of routine urography is not unusual.

In the absence of secondary complications pyelogenic cysts may be left untreated, with subsequent observation. When persistent secondary infection or a stone is present, complete excision usually is indicated. If a cyst is large enough, amputation of the affected renal pole may be advisable.

In a recent review of a series of 163 cases of simple renal cyst in which operation was performed at the Mayo Clinic, Braasch made the following classification of renal cysts, which for his purposes has proved to be practical: (1) retention or inflammatory cysts (usually of little or no clinical significance); (2) simple cysts (single, multiple, multilocular or hemorrhagic); (3) pyelogenic cysts; (4) peripelvic cysts; (5) cysts secondary to renal pathologic change (calculus, hypernephroma, tuberculosis, pyelonephritis, hematoma or echinococcus); (6) polycystic kidneys.

Nephritis.—Lobo Onell and Diaz Muñoz [8] state that the operation of renal decapsulation and denervation in acute glomerulonephritis is innocuous and helpful in halting the progress of the disease in its acute form. Careful judgment is required so that operation shall not be performed in cases in which the condition is amenable to medical treatment. On the other hand, procrastination may lead to irreversible parenchymal changes. Operation should be done at the crucial moment before the disease becomes chronic.

The most striking results were seen in cases of subacute glomerulonephritis.

In cases in which the disease had reached the subchronic phase, the results were variable. While in some instances they were encouraging, in others no appreciable benefit was derived.

As to the chronic form, careful discrimination must be used in the selection of cases. Operation is indicated in acute exacerbations of chronic nephritis and when there are pain and hematuria.

In the vascular forms, in which hypertension is the chief symptom, decapsulation and denervation must be done before the majority of the arterioles are obstructed, so that the full benefit of the resultant vasodilatation can still be had.

Hypertension.—Patton, Page and Ogden [9] review the reported clinical cases of hypertension and unilateral renal disease in which nephrectomy was done. In more than half of these cases either the blood pressure remained at the

7. Braasch, W. F.: Pyelogenic Renal Cyst, Urol. Corres. Club Letter **10**:67-68 (July 19) 1943.

8. Lobo Onell, C., and Diaz Muñoz, I.: Results of Surgical Treatment of Diffuse Glomerular Nephritis, J. Urol. **50**:34-39 (July) 1943.

9. Patton, H. S.; Page, E. W., and Ogden, E.: The Results of Nephrectomy on Experimental Renal Hypertension, Surg., Gynec. & Obst. **76**:493-497 (April) 1943.

same level or it continued to rise after the operation.

This problem was studied in rats in order to determine the factors which influence the success or the failure of nephrectomy in curing hypertension. Permanent high blood pressure was produced by obstructing the blood supply to one kidney, and this kidney then was removed after varying intervals. Corresponding to the results in man, half of the rats did not have any lowering of the blood pressure and only 20 to 30 per cent of the animals were cured of hypertension. In the animals that had residual hypertension, albuminuria persisted, and a histologic study of the remaining kidney revealed numerous vascular changes similar to those observed in the kidneys of human beings with hypertension and apparently accounting for the continued maintenance of the high blood pressure. If the affected kidney had become completely devoid of a blood supply, its removal was a useless procedure. The greatest success following nephrectomy was in those cases in which hypertension was of short duration, and within the limits of the experiments the severity of the hypertension was not of importance in determining the end result.

Aneurysm.—Lowsley and Cannon [10] state that 75 cases of aneurysm of the renal artery have been reported to date, including the case presented in their paper.

A congenital defect in the wall of the renal artery, particularly at its bifurcation, is a hypothetic factor in the causation of aneurysm. It is questionable whether trauma per se produces renal aneurysm.

In only 12 of the 75 reported cases was the condition suspected prior to operation or death.

True aneurysm is usually asymptomatic. A few patients have complained of pain in the flank. The cardinal symptoms of false aneurysm are hematuria, pain and tumefaction in the flank. The pathognomonic signs—pulsation and a systolic bruit—have been present in 7 cases. The presence in the roentgenogram of a ringlike shadow, with a dense periphery disrupted in one portion and a rarefaction of the center, in the kidney or the hilar region, is suggestive of a renal aneurysm.

The treatment is surgical. According to the literature, every patient presenting symptoms on whom operation was not performed died. Of the 29 patients subjected to nephrectomy, 26 survived. Of 37 patients who underwent operation, 8 died—an operative mortality rate of 21 per cent.

Actinomycosis.—Cohen,[11] in a discussion of actinomycosis of the kidney, states that Actinomyces may gain entrance into the body through injuries, such as abrasions or cuts, by being ingested with food or by being inhaled in the form of spores. Isolated infection of the kidney probably occurs as a result of hematogenous spread.

A preoperative diagnosis of renal actinomycosis can be established only by finding the ray fungus in the urine. This is often difficult because Actinomyces may not have a typical form but may resemble cocci and ordinary bacteria. Cultures may give positive proof, but the organism is very slow growing, often requiring several weeks of cultivation. Cultures made by ordinary methods do not reveal the presence of the ray fungus. There are usually no localizing signs or symptoms. Both the retrograde and the excretory pyelograms are without distinctive features.

Cohen reports the case of a man aged 44 years, who complained of pain in the left loin. The patient had had one attack of painless hematuria. Excretory urography showed a calculus in the left ureter, with left hydroureter and hydronephrosis. Later cystoscopic examination revealed a scar in the region of the left ureteral orifice. Following this, a stone was removed by left ureterolithotomy. After operation the patient had some fever and tenderness in the left costovertebral angle. A retrograde pyelogram showed that the hydronephrosis had disappeared. A diagnosis was made of cortical abscesses of the kidney. An exploratory operation was performed. The kidney was found to be considerably enlarged, with a greatly thickened capsule, and through the latter could be seen tiny yellowish abscesses. Examination by a pathologist of a section taken from the kidney revealed actinomycosis. Following operation, the patient was given potassium iodide for several months, and he made a good operative recovery.

Renal Operation for Drainage of Ascitic Fluid.—Ferguson [12] reports a case in which the pelvis of one kidney was anastomosed to the peritoneum in a case of ascites. The patient was a man aged 38 years, for whom a diagnosis of cirrhosis of the liver, ascites and nephritis was made. The usual treatment, such as tapping and the admin-

10. Lowsley, O. S., and Cannon, E. M.: Aneurysm of the Renal Artery, J. A. M. A. **121**:1137-1143 (April 3) 1943.

11. Cohen, D. L.: Primary Actinomycosis of the Kidney: Case Report, J. Urol. **50**:29-33 (July) 1943.

12. Ferguson, C.: Ascites: An Operation for Its Relief; a Case Report, J. Urol. **50**:164-168 (Aug.) 1943.

istration of mercurial drugs, had been tried with only temporary relief. Excision of the right kidney and anastomosis of its pelvis to the peritoneum were performed. This operation was done with the purpose of permanently draining the peritoneal cavity by way of the right ureter. The patient's condition was satisfactory following operation. The vesical output averaged from 1,300 to 1,500 cc. in twenty-four hours. After a necessary modification was carried out, no further ascites occurred. The patient was in good health one year after operation.

ADRENAL GLANDS

Cortical Tumors.—Howze [13] reports a case of bilateral tumor of the adrenal cortex. The patient was a man aged 51 years, whose urogram showed a mass in the right lumbar region and a deformity of the right renal pelvis. On physical examination the mass was found to be multiple, about the size of a grapefruit. A diagnosis of renal tumor on the right side was made. The patient died somewhat later, and at necropsy a tumor of each adrenal gland was found, together with a small metastatic tumor in the myocardium. Both adrenal glands were greatly enlarged, the normal pattern being almost completely replaced by lobulated masses of yellowish tissue with pink streaking, the latter radiating from the central regions toward the outer edges. On the right side this tissue was seen to continue into the hilus of the kidney and to replace in an expansive development practically the entire kidney, leaving only an incomplete narrow shell of essentially normal renal pattern. The left kidney was not involved in the neoplastic process. Microscopic examination indicated that the growth of the adrenal cortex was a carcinoma.

In a review of the literature on adrenal tumors from 1850 to the present time, Howze found reports of 66 bilateral tumors of various types. There are 2 specimens in the Army Medical Museum not yet reported, which make a total of 69. Forty-five of this group appear to be true cortical tumors arising from the cells of the adrenal cortex and are cytologically adenomas and carcinomas. Six bilateral paragangliomas are reported. The remainder are classified as sarcomas of various types, melanomas, a cavernous angioma and a retroperitoneal cyst of undetermined character. In all cases the diagnosis was made at necropsy except in the case of the retroperitoneal cyst, the origin of which was doubtful. The youngest of the patients was a boy 4 days old, and his tumors were described as adenomatous hypertrophy. The oldest patient in whom necropsy revealed true cortical tumors was a man aged 68 years. A majority of the patients were in the fourth and fifth decades of life. Among the patients there were 36 men and 25 women; in 5 cases the sex was not mentioned. The diagnosis was not made in a single instance during life.

Cahill,[14] in discussing Howze's paper on bilateral tumor of the adrenal cortex, states that it is difficult at times to distinguish adrenal tumors microscopically from renal tumors, and some of the sections shown by Howze look like hypernephroma. The differentiation must be done chemically, simply because the adrenal cell and the renal cell are chemically two different things, and long differential chemical staining of cells is the only way to recognize them. Consequently, it is sometimes difficult to determine whether a tumor is of renal origin with metastasis into the opposite adrenal gland. Cahill states that he would not be satisfied with the diagnosis unless pathologic and chemical examinations were made as far as possible to see whether the cells in the tumor are renal cells or adrenal cells. Howze's patient died of acute chronic adrenal depletion (chronic Addison's disease); pigmentation does not necessarily occur in chronic Addison's disease, because apparently the various syndromes of this disease express not only the loss of hormones but the loss of vitamins which goes with depletion of an adrenal gland.

Hyman and Mencher [15] discuss pheochromocytoma of the adrenal gland and report 4 cases. Thirty-five cases of pheochromocytoma for which operation was performed have been reported in the world's literature. In the combined series there were 5 postoperative deaths. Another death occurred two years after operation, of metastasis. That is the only case of malignant tumor reported in the whole group. Pheochromocytoma did not involve either adrenal gland in 4 cases, and occurred more often among women than among men.

The symptom complex is dependent on the discharge of epinephrine or of an epinephrine-like substance into the general circulation. The symptoms produced during spontaneous and

13. Howze, C. P.: Bilateral Adrenal Cortical Tumors: Report of a Case Simulating Renal Neoplasm, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:21-39, 1943.

14. Cahill, G. F., in discussion on papers by Jeck and Orkin, Shupe, Howze [13] and McKenna, Kiefer and Bronstein,[19] Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:63-64, 1943.

15. Hyman, A., and Mencher, W. H.: Pheochromocytoma of the Adrenal Gland, J. Urol. **49**:755-771 (June) 1943.

induced attacks are more or less similar, differing only in severity. A typical history reveals that the patient complains of pounding headache, nausea, dyspnea, orthopnea, palpitation, blanching of peripheral portions of the body, paresthesias, abdominal cramps, vomiting, precordial throbbing and marked weakness. The attacks last for variable periods from minutes to hours, during which time the patient may be in a state of shock. The attacks usually terminate with flushing of the blanched areas, marked perspiration and weakness. During an attack death may occur from shock, pulmonary edema, failure of the left side of the heart or coronary disease or with cerebral manifestations. If surgical treatment is not given, eventually arteriolar sclerosis results because of unchecked vascular tension. The hypertension which then results becomes fixed.

The attacks may occur spontaneously, or they may be induced by any mechanism which calls forth a discharge of epinephrine (pressor response). These causative factors include emotional upset, fear, anger, slight trauma, change of posture and other conditions. Some patients have succumbed without apparent cause after a trivial operation.

Peripheral vasoconstriction is usually marked and manifests itself in several ways. The blood pressure may rise to more than 300 mm. of mercury systolic, with the diastolic pressure at levels of more than 100 mm., only slightly elevated. At the time of the hypertensive phase the pulse is markedly thin or impalpable.

If the attack has lasted for a long period, the patient may be in a state of shock, which is dependent on the prolonged massive introduction of epinephrine into the circulation.

The urine usually is decreased in volume and contains albumin, erythrocytes and casts; glycosuria may be present. Between attacks the urine may be normal.

Pyelography may show a compression of the upper pole of the kidney if the tumor is large. If the tumor is small, there may be no indication from the pyelographic studies that a tumor exists in the region of the adrenal gland. For this type of case perirenal insufflation is essential and easily demonstrates and localizes the tumor.

Medullary Tumors.—Tumor of the adrenal medulla must be differentiated from hyperthyroidism, coronary occlusion and ordinary hypertension.

In the management of patients with tumor of the adrenal medulla, careful preoperative preparation is of paramount importance. Emotional excitement should be avoided. Knowledge of the operation should be withheld from the patient, and sedation should be adequate. The use of solution of tribromoethanol U. S. P. as the basal anesthetic affords opportunity to avoid the excitation which other anesthetic procedures may cause. Extract of adrenal cortex, as well as epinephrine, has been recommended in the management of these patients because of the sudden release from a state of high titer of circulating epinephrine following the operation and because of the possibility of temporary adrenal cortical insufficiency which the loss of adrenal cortical tissue might cause. Furthermore, it has been shown that the administration of an extract of adrenal cortex is of benefit when the circulatory collapse of epinephrine shock is produced. Desoxycorticosterone and salt should also be employed preoperatively, but a word of caution is necessary in regard to this medication. Overdosage should be avoided since it leads to pulmonary edema, to which a patient may succumb.

Preparation is made at the operation for frequent determinations of blood pressure by the anesthetist. Since excessive handling of the tumor causes discharge of large amounts of epinephrine into the circulation, adequate exposure of the area and gentleness of technic are essential. When the tumor is small, lumbar incision with excision of the twelfth rib and if necessary the eleventh rib is advised. However, when the tumor is huge, the transperitoneal approach is more advisable than the lumbar approach. In the lumbar incision, the posterior portion of the usual renal incision is extended upward to parallel the spine to the eleventh rib. After excision of the twelfth rib, the kidney is exposed and packed away toward the iliac fossa. The tumor is located, and a decision is then made as to whether to excise the eleventh rib. Care is taken not to injure the pleura. After being located, the tumor is removed with as little handling as possible. Striking rises of blood pressure may be noted as soon as the tumor is manipulated. Following the removal of the tumor, the blood pressure may fall precipitously. This event calls for a close watch over the patient. In much more than half of the reported cases the patient has suffered from shock during or immediately after the operation. Intravenous infusion, intravenous injection of solution of epinephrine hydrochloride U. S. P. and intramuscular administration of a suspension of epinephrine in oil are indicated for any immediate collapse. Extract of adrenal cortex and desoxycorticosterone are valuable agents in therapy following the epinephrine regimen.

The postoperative care consists of the continuation of the regimen started in the preoperative period. After the shock has been combated successfully, convalescence is uneventful. Further spontaneous attacks cease, and efforts to induce the paroxysms are no longer successful. The results of studies of blood and urine become normal. The response to the various pressor tests likewise does not show any deviation from the normal.

Of the 4 patients whose cases are presented, 3 were women and the fourth was a man. All the tumors were removed successfully, and all the patients made uneventful recoveries. A long period of follow-up reveals that the patients are in excellent health and that no further attacks have occurred.

Cahill,[16] in discussing Hyman and Mencher's article on pheochromocytoma of the adrenal gland, states that the patients present a hormonal or paroxysmal type of hypertension, which is distinct from the continuous essential type, which most likely is due to some amino acid. In both of these types of hypertension, correction is necessary before the patient is permanently injured.

Pheochromocytomas are usually benign and occur mostly in adults. In some cases of major hysteria there are attacks which resemble the hormonal crises occurring with pheochromocytoma.

When the classic symptoms are present, the first diagnostic step is to prove the presence of excess hormone. The next step is to prove its source, which has been done best by perirenal insufflation of air. After the tumor has been located, its removal is necessary. The anesthetic agent of choice is solution of tribromoethanol U. S. P.

In operations on adrenal tumors, it is best to remove a malignant cortical tumor through a transperitoneal approach. For a benign tumor, such as pheochromocytoma, the flank incision is adequate. Ligation of the blood supply should precede the handling of the tumor.

It has been the experience of most surgeons that the blood pressure remains low for some time after the removal of a pheochromocytoma, but if the patient survives the operation, cure usually follows; in other words, hypertension due to this tumor is a type of hypertension that can be cured.

MacKenzie[17] states that he has seen 4 patients who had pheochromocytoma of the adrenal gland but that his results have been not quite so satisfactory as those of Hyman and Mencher, for 1 patient died.

He discusses a case in which he operated five years ago. The patient was a man of 29 years. There were several things which were interesting about this patient. One was that he always had a sudden spasmodic rise of blood pressure when pressure was applied in the region of the left kidney, but none when pressure was applied over the right kidney. He was admitted to the neurologic service with a tentative diagnosis of tumor of the brain. At operation, the left side was explored and found to be normal; then, on the right side, a large tumor was found. When the patient was dismissed, his blood pressure was 110 systolic and 70 diastolic. From then on, the highest pressure reading was reported to be 120 systolic and 80 diastolic. About four months ago, while taking his gymnastic exercises in the morning, bending forward, he got one of those attacks; as he said, "not very severe, but there is no question but that the attack is the same as experienced before operation." Following that, he had five or six attacks before returning for treatment. None of these attacks was as severe as the previous ones, but they were definite. He entered the hospital about a month ago and was able to produce the attacks by his gymnastic exercises, but pressure in the renal regions produced no change. Exposure of both adrenal glands at operation revealed them to be normal. While the patient was on the operating table, MacKenzie tried flexing the patient's body by bending the thighs against the abdomen. This was followed by a rise of the blood pressure to 282 systolic and 166 diastolic.

Mencher[18] states that pheochromocytoma produces a type of hypertension paroxysmal in nature and remediable by surgical treatment. It is important that a diagnosis be made and surgical treatment rendered before the hypertension becomes fixed.

Pseudohermaphroditism and Adrenal Disease.—McKenna, Kiefer and Bronstein[19] discuss pseudohermaphroditism in relation to the adrenogenital syndrome. They present 2 cases in which an operation was done and a third case in which the diagnosis was made clinically but no surgical treatment was carried out.

The first case was that of a girl aged 14 years. The patient always had known that she had an

16. Cahill, G. F., in discussion on Hyman and Mencher,[15] p. 772.

17. MacKenzie, D. W., in discussion on Hyman and Mencher,[15] pp. 772-773.

18. Mencher, W. H., in discussion on Hyman and Mencher,[15] pp. 775-776.

19. McKenna, C. M.; Kiefer, J. H., and Bronstein, I. P.: Pseudohermaphroditism Due to Hyperactivity of the Adrenal Cortex, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:41-58, 1943.

enlarged clitoris, which recently had been enlarging rapidly. In general, she was a muscular child, having more male characteristics than female. There was a marked growth of suprapubic hair with the male type of escutcheon extending up to the umbilicus. There was a rather large phallus, about 2 cm. in diameter and about 4 cm. long, of the hypospadic type with ventral curvature. At the base of this phallus was what at first seemed to be a urethra; however, on closer examination a vaginal orifice was seen; on spreading this the urethral orifice could be seen immediately inside. It was possible to do a vaginal examination with one finger, and the small, apparently normal uterus was palpable. No masses were found in the pelvis. Cystoscopic examination revealed a normal bladder and urethra. On abdominal exploration a normal uterus was found; the ovaries appeared undeveloped. At a second operation, both adrenal glands were exposed. The right adrenal gland was somewhat enlarged, and a part of it was removed. Later the clitoris was amputated and the perineum opened more widely to establish a more normal female condition of the genitalia. Five months later the patient was in good general health; the body contours were more feminine, and there was beginning development of the breasts.

The second case was that of a girl aged 4 years. The genitalia had been noticed to be abnormal at birth but were predominantly female. Examination revealed a large phallus, 2 cm. in diameter and 4 cm. in length. There was a perineal urethral meatus, and no division of this canal could be seen when the meatus was spread. An abdominal exploratory operation was carried out. The uterus and the ovaries were normal but small. Injection of air into the perirenal space on the left side showed the left adrenal gland to be approximately 20 by 30 mm. in outline; the right adrenal gland was not outlined. The right adrenal gland was then exposed surgically and three fourths of it resected. Examination of the sections led to a diagnosis of cortical adenoma of the adrenal gland and diffuse and focal pseudonodular hyperplasia of a disordered adrenal cortex.

URETER

Calculus.—Beach [20] states that ureteral calculus is common in the Sacramento Valley, in California.

Watchful waiting is advisable, since spontaneous expulsion of the calculus is fairly frequent. Error in judgment, or leaning too far toward conservatism, however, may result in increased morbidity and perhaps otherwise avoidable mortality.

Beach's expectant treatment consists of insertions of a soft indwelling ureteral catheter, left in situ for twenty-four to forty-eight hours, under aseptic conditions. On withdrawal of the catheter, sterile olive oil is injected, and prostigmine methylsulfate is given hypodermically, with the patient ambulant. An aid to securing ureteral relaxation for the removal of large stones is found in deproteinated pancreatic extract, administered just before instrumentation. Metal forceps and metal-tipped stone dislodgers do not have any place in instrumentation within a ureter weakened by stone, as demonstrated in 3 cases observed by the author, in which perforation occurred.

Failure to respond to a reasonable trial of manipulative measures should be followed by open operation.

About 75 per cent of ureteral stones reach the prevesical spindle. If ureteral meatotomy is necessary, the use of scissors or a cold knife is preferable to fulguration.

Beach warns that the position of the stone must be rechecked immediately before operation.

Carcinoma.—Scott [21] reports 2 cases of carcinoma of the ureter and states that this lesion occurs more frequently in the sixth and seventh than in other decades of life. The youngest patient noted in a review of the literature was 22 years of age and the oldest 89 years of age. Of the patients whose sex was stated, 33.7 per cent were women and 66.3 per cent were men.

The right ureter was involved in 67 per cent of the cases, and the lower end of the ureter in 52 per cent.

More than 50 per cent of the tumors were papillary.

The postoperative mortality rate was 24 per cent. Only 6 patients were reported living and well more than four years after operation, but many of the patients were not followed. Of 32 reported well, only 6 were followed four years or more.

Earlier diagnosis and use of operative procedures that have as their first consideration the removal of the primary lesion with the least possible risk to the patient should decrease the postoperative mortality rate and improve the end results.

20. Beach, E. W.: Ureteral Calculus: Its Management, California & West. Med. **58**:113-118 (March) 1943.

21. Scott, W. W.: A Review of Primary Carcinoma of the Ureter: Presenting Two Cases, J. Urol. **50**:45-64 (July) 1943.

Injury During Gynecologic Operations.—Adams [22] discusses ureteral injury incurred during gynecologic operations, presenting data on a series of 73 cases collected from the literature between 1936 and 1941; he also reports 3 new cases. No information as to the frequency of this accident is available from his study. Sampson has reported 16 cases of ureteral injury occurring at the Johns Hopkins Hospital between 1889 and 1902 in 4,086 major gynecologic procedures, an incidence of 0.4 per cent. Likewise Newell in 1939 found an occurrence of 0.4 per cent in 3,144 hysterectomies. Ureteral injury can pass unrecognized; Newell reported 15 cases, in 6 of which the injuries were not recognized until found at necropsy.

In the present series the injuries were unilateral in 50 cases and bilateral in 17. There are five general types of injuries: (1) ligation, (2) incision, (3) excision, (4) necrosis and (5) obstruction from surrounding postoperative edema and inflammation.

The most concise tabulation of the sequelae of ureteral damage in cases in which this condition has not been discovered at the time of operation has been formulated by Robinson and is quoted by Adams: (*a*) Bilateral damage: (1) double section followed by leakage, general infection and death (or formation of a fistula); (2) double ligation followed by anuria and uremia, fatal if unrelieved. (*b*) Unilateral damage: (1) section followed by leakage and acute infection either local or widespread; (2) partial section with leakage and ureteroabdominal or ureterovaginal fistula; (3) ligation followed by atrophy of the kidney, with or without symptoms of renal inadequacy, and in some cases by acute or chronic uremia; (4) ligation with reflex suppression and complete anuria. (*c*) Partial occlusion or kinking from periureteral adhesions following various abdominopelvic operations. Adams adds the following two classifications: (*d*) Unilateral or bilateral ligation with delayed formation of a fistula. (*e*) Unilateral or bilateral occlusion from edema and inflammation with spontaneous reestablishment of renal drainage.

The treatment of the ureteral injury depends on when the condition is recognized and what type of damage has occurred. When the injury is recognized during the course of an operation, immediate restoration of the continuity of the kidney and the bladder should be attempted. In the present series the condition was recognized only eight times, compared with sixty-seven times that the accident was not discovered until the postoperative period.

When the ureter has been severed, the two procedures of choice are ureteroureteral or ureterovesical anastomosis.

Voluntary ligation of the proximal end of the ureter should be done only when the patient is in such poor condition that further operative procedure will seriously endanger her life.

When clamping or ligation of the ureter is recognized at the time of operation, the clamp or the ligature should be removed immediately. However, a clamp or a ligature, even though left on for only a short time, often will jeopardize the integrity of the ureteral wall. When any doubt of ureteral integrity exists, it is better to excise the damaged portion and to do a ureteroureteral or ureterovesical anastomosis.

In 2 of the 8 cases in which damage was recognized at the time of operation it was treated by ureterovesical anastomosis, with a good result in 1 and ureteral stricture and renal atrophy in 1. In another case the damage was corrected by implanting the ureter into the bowel, with a good result. In 5 cases ureteroureteral anastomosis was attempted; good results were obtained in 3; in 1 instance in which this operation failed to give a good result the function was good after dilation of the ureter but the unavoidable discontinuance of dilation resulted in ureteral stricture. There was 1 death.

A study of the data on cases collected by Adams together with a series collected by Feiners yields several interesting facts:

Ureterovesical anastomosis was done in 70 cases. In 8 (11.4 per cent) the result was considered to be perfect; a fair result (some residual stenosis) was observed in 38 (54.3 per cent). In 21 (30 per cent) the result was a failure and in 3 (4.3 per cent) the operation was followed by death of the patient.

In 30 cases ureteroureteral anastomosis was performed. In 21 (70 per cent) it yielded a successful result, in 6 (20 per cent), a failure; in 3 (10 per cent) death followed the operation.

In 23 cases in which the ureter was ligated intentionally there were two deaths, while in 53 cases of nephrectomy there were only two deaths, an incidence of 3.8 per cent. It would seem, therefore, that when the kidney is to be sacrificed, nephrectomy is the better of the two procedures.

There were 25 cases in which the fistula was reported to have healed spontaneously. However, in 10 of these subsequent study showed the kidney on the affected side to have been destroyed. Spontaneous closure of a fistula in

22. Adams, T. W.: Ureteral Injury During Gynecologic Surgery, West. J. Surg. **51**:305-320 (Aug.) 1943.

these cases, therefore, should not be looked on with a great feeling of security.

Of the 255 cases in which secondary procedures were carried out, death or removal of one kidney occurred ninety-four times.

Bilateral ureteral occlusion cannot go long unrecognized. The symptoms are anuria and gradually developing uremia. Failure to obtain urine from the bladder in twelve hours following a pelvic operation calls for immediate investigation. Should this investigation prove bilateral ureteral occlusion, immediate steps must be taken to establish urinary drainage. In the present series, anuria was the first symptom noted in 16 of the 17 cases. The length of time that the anuria was allowed to proceed before relief measures were undertaken was from twelve hours to six days.

In these cases the primary object is the immediate relief of the anuria. There are in general two methods of attack: (1) reestablishment of drainage of the ureteral tract; (2) temporary replacement of drainage above the point of injury by either unilateral or bilateral nephrostomy or ureterostomy.

Spasm.—Lund and Zingale [23] discuss a synthetic hydrocarbon (methylaminoisooctene) for the relief of ureteral spasm, reporting a series of 100 consecutive cases in which the drug was used.

In 80 cases there was obtained a varying degree of relief. In 50 per cent of these relief was complete. In 30 per cent there was relief sufficient to cause the patient to feel comfortable. In the remainder of the cases, 20 per cent, there was no relief. In this last class are included patients that were having postcystoscopic colic; it was assumed that the causative factor, the radiopaque solution, had not been drained off completely and remained as an irritant. In this class also are those patients in whom a demonstrable foreign body was present.

In 8 cases, Lund and Zingale believe, the drug was instrumental in causing spontaneous passage of stones that were present.

There were 2 patients with sensitivity to the drug. This sensitivity was manifested by a feeling of light-headedness and increased nervous irritability, and 1 of these experienced difficulty in swallowing. These effects were transient and occurred among unusually apprehensive women.

There was no cumulative effect or habituation.

This synthesized aliphatic hydrocarbon is a sympathomimetic drug and probably acts on the true sympathetic endings which are inhibitory to the ureters. With the dosage used, side effects have been negligible. The drug has been effective in ureteral colic due to stone, postcystoscopic colic, ureteral spasm following pyelography and ureteral hyperirritability on a neurogenic basis; it has assisted the passage of stones. In Lund and Zingale's opinion it is a most effective ureteral antispasmodic.

Injury by Radium.—Smith and Leadbetter [24] report 5 cases of ureteral obstruction following radium treatment of the cervix or the vagina. In 2 of these, microscopic examination of the ureter and of the adjacent vesical wall did not show any cancer cells; in 1 instance the complete restoration of the ureteral lumen following nephrostomy may be accepted as proof that the obstruction was not directly due to cancer. From the evidence at hand it appears that obstruction is caused much more frequently by radium than by roentgen therapy. If the obstruction involves the intramural portion of the ureter and appears to be due to late radiation effect rather than to infiltration by cancer cells, temporary diversion of the urine by means of nephrostomy is indicated. If the obstruction develops at a higher point, permanent urinary diversion by nephrostomy or by ureterostomy usually will be necessary.

BLADDER

Calculus.—Nation [25] reports a case of large vesical calculus in association with gigantism. The patient, a 33 year old man, had had symptoms for only a short period. He was 6 feet 4½ inches (194 cm.) tall, with characteristics suggestive of gigantism. A roentgenogram of the bladder revealed a shadow 8 by 10 cm. in the region of the bladder and a somewhat smaller one below this. Cystolithotomy was carried out and the stones removed. The patient made an immediate operative recovery but died twenty days later.

Abramson [26a] discusses the solution of vesical phosphatic calculi. He reports a case demon-

23. Lund, H. G., and Zingale, F. G.: Synthetic Hydrocarbon for the Relief of Ureteral Spasm, J. Urol. **50**:65-67 (July) 1943.

24. Smith, G. G., and Leadbetter, W. F.: The Effect of Irradiation on the Lower Ureters, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:195-203, 1943.

25. Nation, E. F.: Large Vesical Calculus in Association with Gigantism, California & West. Med. **59**: 167-169 (Sept.) 1943.

26. (*a*) Abramson, D. J.: Solution of Vesical Phosphatic Calculi, J. Urol. **50**:197-201 (Aug.) 1943. (*b*) Suby, H. I.; Suby, R. M., and Albright, F.: Properties of Organic Acid Solutions Which Determine Their Irritability to the Bladder Mucous Membrane and the Effect of Magnesium Ions in Overcoming This Irritability, ibid. **48**:549-559, 1942. (*c*) Suby, H. I., and Albright, F.: Dissolution of Phosphatic Urinary Calculi by the Retrograde Introduction of a Citrate Solution Containing Magnesium, New England J. Med. **228**:81-91 (Jan. 21) 1943.

strating the efficacy of citric acid–magnesium oxido–sodium carbonate solution ("solution G" [Suby, Suby and Albright[26b]; Suby and Albright[26c]]) in dissolving a vesical calculus when surgical intervention was contraindicated. The patient was a man aged 64 years, who had nocturia, dysuria and urgency. Cystoscopic examination revealed an enlarged prostate. Suprapubic cystotomy was done, and later transurethral resection. The patient responded poorly to surgical treatment. In due time the suprapubic sinus closed. At a later date the patient had symptoms suggesting a vesical calculus. A roentgenogram showed a shadow 2 by 3 cm. in the region of the bladder. Because of his advanced age and the poor condition of his heart, an attempt was made to dissolve the stone with the citric acid solution. Irrigations were started and continued for six days. The washings contained a great deal of sediment. On cystoscopy the calculus was found to be considerably reduced in size. Later cystoscopy revealed that the calculus had disappeared.

Abramson also discusses the prophylaxis of vesical phosphatic calculi. Stasis from whatever cause must be corrected. Sulfonamide compounds have proved of some value in combating infections caused by Bacillus coli, Bacillus proteus or staphylococci. Other drugs include mandelic acid, methenamine and ammonium chloride. The acid ash regimen may be prescribed to render the urine acid and thus prevent precipitation of phosphates. The urine should be maintained approximately at p_H 5.0. In the presence of a persistent alkaline infection, however, the p_H of the urine cannot usually be changed to the acid side. Fluids, preferably distilled water, should be forced. The more dilute the urine, the less chance there is of precipitation occurring. Vitamin A in large doses is indicated. Lavage with antiseptic and dilute acid solutions is of value. The citric acid solution is also effective in the treatment of alkaline incrusted cystitis.

Carcinoma.—Priestley and Strom[27] state that until recent years total cystectomy for carcinoma of the bladder usually had been employed only for the far advanced and so-called desperate type. Only for this type could the surgeon justify a procedure which was attended by so high an operative mortality rate. Total cystectomy has been employed for the most part in cases in which many forms of treatment had been tried previously and in which all other measures had proved to be futile. Obviously this means that the growth is of long standing.

In these cases, regarding a second objection, namely, the high immediate postoperative mortality rate, it has been observed that the bladder can be removed completely with a reasonable mortality rate provided proper attention is paid to preoperative and postoperative care as well as to the actual surgical technic. If the operative mortality rate of bilateral ureterosigmoidostomy and total cystectomy can be kept within a reasonable limit, the application of this method of treatment for vesical neoplasm should become broader than it is at present, provided of course, one admits that there are certain types of cases for which the operation gives the best chance of cure.

Indications for total cystectomy in the treatment of carcinoma of the bladder are far from standardized. This is true largely because there is lacking experience with a large series of cases in which operation has been performed a number of years previously, so that ultimate survival rates could be ascertained in relation to the types of lesion present. During the last few years Priestley and Strom have employed total cystectomy in four main groups of cases with the hope of determining as time passes whether these indications are correct. These groups of cases include (1) cases in which there is great extension of a low grade neoplasm, (2) cases in which there is repeated recurrence of a low grade neoplasm, (3) cases in which there are multiple foci of origin of the neoplasm and (4) cases in which there is a high grade neoplasm which remains confined to the bladder so far as the best available information, obtained by both clinical investigation and exploratory operation, shows.

The best ultimate results following total cystectomy probably will be observed in the first three groups of cases, as the high grade lesion is likely to recur in one form or another despite any type of treatment.

There is also another group of cases in which total cystectomy may be employed. These are the cases in which the neoplasm is sessile and involves the trigone and the base of the bladder. Often under these circumstances some disposition must be made of the ureters if the lesion is to be removed completely by any form of therapy.

The most satisfactory plan of procedure, in Priestley and Strom's opinion, is simultaneous bilateral ureterosigmoidostomy followed after an interval of two or three weeks by total cystectomy combined with removal of the prostate gland and the seminal vesicles. One may trans-

27. Priestley, J. T., and Strom, G. W.: Total Cystectomy for Carcinoma of the Bladder, J. Urol. **50**:210-227 (Aug.) 1943.

plant each ureter to the bowel at a separate stage and remove the bladder at a third operation.

One of the factors which are most important in obtaining satisfactory results following ureterosigmoidostomy is proper preoperative preparation of the patient. Priestley and Strom carry out a program similar to that employed before resection of the large bowel for carcinoma. This includes a regimen of preparation extending over a minimum of four days. During this interval the patient should receive a residue-free liquid diet with supplements of hard candy and vitamins. During the first three days of preparation a saline laxative is given in the morning and again in the evening. One of the sulfonamide drugs which is effective in reducing the bacterial content of the gastrointestinal tract should be administered in adequate doses every two hours during the four days of preparation. During the first several days an enema of generous size is given each morning and each evening. During the last two days of preparation the rectum is irrigated with warm saline solution twice a day until the returns are clear. On the night prior to operation the saline laxative and the rectal irrigation are omitted and 2 fluidrachms (7.4 cc.) of camphorated tincture of opium U. S. P. is administered at 6 and at 10 p. m., and aspiration of the rectum is conducted for thirty minutes at the same time. On the day of operation 2 fluidrachms (7.4 cc.) of camphorated tincture of opium U. S. P. is given and rectal aspiration is conducted for thirty minutes at 6 and at 8 a. m.

Simultaneous bilateral ureterosigmoidostomy is then performed.

Following bilateral ureterosigmoidostomy, the rectal tube is kept in place for a week or ten days. During this interval care must be taken that the tube does not become plugged. Removal of the bladder is postponed until the patient has recovered his strength fairly well and is able to be out of bed for a few days. This usually means an interval of approximately three weeks between the two operations.

Spinal anesthesia, often combined with intravenous administration of pentothal sodium, is used for removal of the bladder. The patient is placed in the Trendelenburg position, and the bladder is exposed extraperitoneally through a low midline incision. If there is no extension of the malignant process into the perivesical tissues, the bladder can be mobilized by blunt dissection for the most part. Sharp dissection is employed where necessary. Generally it is preferable to mobilize first the side of the bladder in which the neoplasm is not present by pushing the peritoneum back and dissecting away the perivesical tissues down toward the base of the bladder.

By blunt dissection the seminal vesicles and the prostate are separated from the rectum and mobilized with the bladder. The bladder then is freed upward anteriorly, and after complete mobilization, is held attached only by the urethra. This is severed distal to the verumontanum. It is preferable for several reasons to remove the prostate and the seminal vesicles along with the bladder. If these are not removed, recurrence of the vesical neoplasm may take place in the prostatic urethra, as occurred in 2 of the earlier cases in the experience of Priestley and Strom. Occasionally, if the growth in the bladder is situated in the region of the trigone, it may have penetrated into the prostate, a condition which would make removal of the latter desirable. In addition, one may find an entirely independent and unsuspected neoplasm of the prostate. Removal of the bladder, seminal vesicles and prostate together can be accomplished more readily than removal of the bladder alone. If one removes only the bladder and leaves the prostate and the seminal vesicles intact, dissection around the base of the bladder is more difficult and lines of cleavage are less satisfactory than if the prostate and the seminal vesicles are removed with the bladder. Total cystectomy is easier in women than in men and does not present any special problems when a woman is the subject.

Priestley and Strom recently made a review of the records of 105 patients with carcinoma of the bladder on whom operation was performed at the Mayo Clinic between 1910 and Aug. 31, 1942, inclusive, with a view to performing total cystectomy. The operations were performed by seven different surgeons. In approximately 1 of every 5 patients the growth was considered to be inoperable, and exploration and biopsy alone were done. In a group of 71 patients in whom urinary diversion was accomplished by various methods as a preliminary step to cystectomy, the operative mortality rate (hospital deaths) was 23.9 per cent. Of this group of 71, bilateral ureterosigmoidostomy was performed in 51, with a mortality rate of 15.7 per cent. In the remaining 20 patients, many of whom were in unusually poor condition, urinary diversion was accomplished by other methods, with a mortality rate of 45.0 per cent. In 4 of the entire group of 71 patients ureteral transplantation was performed as a palliative procedure, and 2 of these patients failed to survive the operation. Of the patients who survived transplantation, cystectomy was performed in 52, with six deaths, or a

mortality rate of 11.5 per cent. In addition, transplantation and total cystectomy were performed in one stage in 13 patients, with eight deaths, or a mortality rate of 61.5 per cent.

It is of interest to review in contrast with these figures the experience of the past three years. During this interval ureteral transplantation has been performed in 29 patients, with one death. Simultaneous bilateral ureterosigmoidostomy was the method of transplantation employed in 27 of these 29 patients. Of the 28 patients who survived ureteral transplantation and in whom cystectomy was accomplished, 1 died. Thus, the operative mortality rate in 29 patients for both operations was 6.9 per cent. In 5 additional patients ureteral transplantation and cystectomy were performed in one stage, with one death.

In all there were 51 patients who survived total cystectomy for carcinoma of the bladder. Of this group, 26 have succumbed since operation, and 15 of these died within the first postoperative year; the remainder died at intervals ranging from one to six and a fourth years after operation. The cause of death was ascertained for 20 of the group of 26 patients. Metastasis was the cause in 16; in 4 death resulted from renal failure. A review of the records of the patients who died of metastasis reveals a fact which appears significant: In 13 of this group extension of carcinoma beyond the bladder either to the perivesical tissues or to the regional lymph nodes was noted at the time of operation. Because of this fact it appears unwise to perform cystectomy if the growth has extended beyond the bladder in such a manner that its complete removal is questionable. Of the group of 51 patients who survived cystectomy, 24 are still alive and 1 could not be traced.

Abeshouse and Goldstein [28] review 89 reported cases of primary malignant neoplasm in a diverticulum and add data on 4 personal cases. They state that primary neoplasm in a diverticulum is essentially a disease of men and occurs most frequently between the ages of 50 and 65 years. The growth may be benign or malignant and closely simulates that originating in the bladder. The most common tumor observed is a carcinoma of epithelial origin, either squamous cell or papillary carcinoma. The most common and most important symptom is hematuria. Other symptoms frequently noted are those associated with infection of the bladder and the diverticulum or obstruction of the vesical neck.

Cystoscopy and cystography are important diagnostic aids. The diagnosis is made easily in cases in which a portion of the tumor protrudes through the orifice of the diverticulum and can be seen through the cystoscope or in which the tumor can be visualized directly when the cystoscope is introduced into the diverticulum. In the diverticulogram bleeding from the orifice of the diverticulum and filling defects are strongly indicative of a tumor.

Every diverticulum observed at operation, regardless of its cause, should be exposed and inspected carefully, and if suggestive of cancerous growth, it should be removed. The diverticulum containing the neoplasm may be also the seat of infection or of a stone. Lesions of the urinary tract are frequent complications of this condition.

Surgical treatment has been far from satisfactory but yields better results from the standpoint of symptomatic relief and cure than nonoperative treatment. The operation of choice is excision of the diverticulum and tumor by the suprapubic intravesical or extravesical method or a combination of the two. Patients who have extensive local or general metastatic growths or severe infection of the urinary tract and those who are poor surgical risks should not be subjected to radical operative treatment. The prognosis is bad, as relatively few cures are reported, and the majority of patients succumb within two years after operation.

Rupture.—McCague [29] discusses the factors influencing mortality and morbidity in patients with intrapelvic rupture of the urethra and bladder. The incidence of urethral injury due to external violence is not high. The incidence of traumatic rupture of the urethra and bladder that occurs as a complication of fracture of the bony pelvis is somewhat higher in the Pittsburgh district than in any other area recorded in the literature—this by reason of the large numbers of men employed in the heavy industries, especially the coal mines and the steel mills. Fifty-two cases of pelvic fracture were encountered by McCague from January 1940 to May 1942. Five patients suffering from rupture of the urethra and bladder complicating pelvic fracture have been admitted to McCague's service since Pearl Harbor. All the injuries except 1 were due to industrial accidents. Such an injury sustained in a coal mine is usually the result of the patient's being crushed between the mine

28. Abeshouse, B. S., and Goldstein, A. E.: Primary Carcinoma in a Diverticulum of the Bladder: A Report of Four Cases and a Review of the Literature, J. Urol. **49**:534-557 (April) 1943.

29. McCague, E. J.: Factors Influencing Mortality and Morbidity in the Intrapelvic Ruptures of Urethra and Bladder, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:307-316, 1943.

timbers and a coal car or of his being buried beneath a fall of slate. The damage is violent and mutilating; usually there are multiple fractures of the pelvis, intrapelvic rupture of the urethra and bladder, frequently associated visceral injuries and shock so profound that many of the patients die (23 per cent) before or in spite of all remedial measures.

Diagnosis may be difficult. With rare exceptions the patient is admitted in profound shock; there are extreme pain on movement and inability to move the legs, which generally are rotated outward. The patient is unable to void, and blood may be seen trickling from the meatus. Palpation of the iliac crests and compression of the pelvis cause great pain, and crepitus usually can be elicited. The urethra generally is severed and displaced posteriorly; the rectum is compressed and a tender boggy mass may be felt and bony deformity outlined. Perineal and scrotal ecchymosis or hematoma may be present. Unless there is an associated rupture of the bladder, these patients do not extravasate urine early, owing to the reflex action of the sphincter.

If there is an associated rupture of the bladder, there is marked tenderness in the lower part of the abdomen, usually over the site of the rupture, and the rapidly developing hematoma produces a palpable tender mass, enlarging and distorting the lower part of the abdomen. There is nearly always traumatic ileus, which makes the diagnosis of intraperitoneal rupture of the bladder or visceral injury difficult. As a rule, however, intraperitoneal injuries are more dramatic than extraperitoneal injuries; there are greater shock, a rigid boardlike abdomen, absence of peristalsis and great tenderness, whereas in extraperitoneal rupture of the bladder tenderness is more marked in the lower part of the abdomen. In McCague's opinion, the passing of a catheter in these cases is rarely indicated, and the information gained is misleading and unreliable.

In McCague's opinion, refinements of diagnosis are rarely necessary for intrapelvic rupture of the urethra and bladder. They have little or no influence on the management, and the unnecessary movement and manipulation of a badly fractured pelvic girdle may increase the gravity of the condition. The delay necessary and the additional trauma may be factors in mortality. Instrumentation of any sort is definitely contraindicated in these cases.

The major cause of death in the patients with intrapelvic injuries who survive the primary injury is urinary extravasation and sepsis. Among those that have an intraperitoneal complication, i. e., intraperitoneal rupture of the bladder and associated visceral damage, the cause is urinary extravasation and peritonitis.

The main causes of morbidity are: failure of early preservation of the continuity of the urethra, causing long-standing complications difficult to correct; formation of calculi with grave damage to the urinary tract unless prevented; loss of sexual power, due to injury of the nerve supply or of the cavernous bodies, and early infection of the soft parts of the pelvic cage with secondary involvement of the bony structures.

McCague stresses the importance of immediate preservation of the continuity of the urethra. Failure to do so results in serious complications. There is a large gap between the torn ends of the urethra. This space is filled with fibrous tissue, making extensive secondary operations for the correction of the defect necessary—procedures that are difficult and not always satisfactory in accomplishment.

McCague has not resorted to sutures and anastomosis in these cases; it is not necessary and lengthens the operation. The retrograde splinting of the entire urethra, with the legs in extension, has been sufficient for approximation and epithelization.

Formation of calculi is fairly common in this group by reason of the marked increase of urinary excretion of calcium, the stasis and the infection, as well as the prolonged rest in bed. Measures to prevent this complication are maintenance of the urinary p_H on the acid side, high acid ash diet, acidifying medication, frequent elevation of renal level and administration of large quantities of fluids.

In McCague's clinic the formation of stricture has been encountered more frequently in the straddle injuries than in intrapelvic ruptures. Periodic dilation is necessary.

Impotence occurs as a complication in a small number of these cases, owing to injury of the nerve and blood supply or of the cavernous bodies.

Diverticula.—Llanos [30] states that the majority of the diverticula of the bladder are congenital but that some are produced by obstruction to urination of long standing or are, at least, small congenital diverticula that did not exhibit any symptoms until they were enlarged because of urinary obstruction, the pedicles becoming narrowed and elongated, resulting in conditions that produce more or less accentuated disturbances.

The seriousness of the diverticula depends in large measure on their location. Those of the posterior wall—immediately behind the trigone—

30. Llanos, M. A.: Diverticula of the Bladder, J. Urol. **49**:628-638 (May) 1943.

and those in the ureteral region are the most serious, the former by reason of the difficulty of their resection, and the latter for the same reason and because of the effect on the corresponding kidney.

When besides the diverticulum there exists an obstruction making micturition difficult, it is necessary first to remove the obstacle and observe the result; if the symptoms persist, diverticulectomy should be performed except in cases in which there is present an intravesical obstacle that can be removed easily, as in contracture of the vesical neck or of the median bar. In such cases, if the condition of the diverticulum indicates that the disturbances could persist after the removal of the obstruction, the diverticulectomy and the resection of the vesical neck or of the median bar should be performed during the same operation.

Kretschmer [31] states that diverticula do not occur without obstruction. Therefore, in the treatment of diverticula it is imperative that the obstruction at the vesical neck be removed completely if one wishes to cure the diverticulum or diverticula. For a good many years he has not operated on diverticula, believing that all that was needed was complete removal of the obstruction. On the other hand, there may be exceptions to this rule so that it becomes necessary to perform diverticulectomy. When the diverticulum is unusually large, or when it does not empty and infection persists, or when as a result of its location it presses on the ureter, Kretschmer believes that diverticulectomy should be done. It is distressing to note instances in which a very small diverticulum is removed by a surgical operation but no attempt is made to relieve the obstruction at the neck of the bladder.

Schistosomiasis.—Burt, Lane and Hamilton [32] report a case of bilharziasis, or schistosomiasis, in a man aged 38 years, whose chief complaint was hematuria.

They state that the condition is hardly likely to be introduced into the United States and perpetuated here, as the cycle of development of this fluke depends on its passage through a species of snail which is not found in America. Therefore, the disease will be self limited unless some American species of snails heretofore unexposed might be found to have this ability of acting as an intermediate host.

The urinary system is the part most frequently involved by far but not the only one. Reports have been made of nodules found in the appendix containing many schistosomes. Hepatic abscesses containing the flukes have been reported also. By far the most common initial symptom is painless hematuria, at first unattended with pyuria. Infection soon supervenes, giving the usual picture of urinary sepsis. Cancerous involvement of the bladder is a frequent implantation on schistosomal infection, as are also formation of calculi and formation of a urinary sinus, which is particularly resistant to treatment.

The cystoscopic appearance of the lesion in the reported case was that of definite elevation of the epithelium in three locations, one midway in the wall of the bladder above the trigone and one on each lateral wall. These elevated areas were deep red, and around the periphery of each were small nodules having the appearance of pustules. One of these pustules apparently had erupted, leaving a small irregular-shaped ulcer. These pustule-like formations, which were arranged around the border of the elevated epithelium, may be likened to the lesions seen in cystitis cystica except that they had a grayish yellow appearance rather than the transparent appearance seen in cystitis cystica.

The diagnosis in this case was made from the appearance of the lesion seen with the cystoscope and from the finding of the specific ova in the urine. When once observed, these pustules will not be forgotten easily, but they are not always seen, as one may make the examination after they have broken down and coalesced into an irregular ulcer having no definite characteristics.

Antimony and potassium tartrate U. S. P. is the drug of choice in schistosomiasis. Not all physicians in Egypt are as optimistic concerning the specific action of this drug as textbooks lead one to believe. The sequelae imposed on schistosomiasis are of course surgical in nature and present the usual surgical problems.

Cystitis Emphysematosa.—Burns [33] reports a case of cystitis emphysematosa. The literature contains reports of about 30 cases, in only 5 of which the condition was diagnosed while the patient was living and in only 3 by cystoscopy. A gas-producing anaerobic bacillus resembling Clostridium welchii was cultured from the urine. This confirmed a previous observation, and it is suggested that this may be the etiologic organism rather than Bacillus coli among those patients who do not have diabetes mellitus. The plain roentgenogram of the region of the bladder has

31. Kretschmer, H. L., in discussion on Trabucco, Gonzales-Iman, Llanos,[30] Davalos and Rebaudi, J. Urol. **49**:649-650 (May) 1943.

32. Burt, J. C.; Lane, C. M., and Hamilton, J. L.: Report of a Case of Bilharziasis, J. Urol. **50**:68-70 (July) 1943.

33. Burns, R. A.: Cystitis Emphysematosa: A Case Report, J. Urol. **49**:808-814 (June) 1943.

a pathognomonic appearance in the original films. The shining light reflected from the individual gas-containing cysts on cystoscopy is so characteristic as to be unmistakable for any other condition. The transient nature of the condition probably accounts for its rare description.

Vesicovaginal Fistula. — Valmé [34] discusses transvesical (suprapubic) closure of a vesicovaginal fistula. The bladder should be opened suprapubically, disclosing the fistula, which is usually a little above the vesical neck. In one of the cases in which Valmé operated, the fistula was parallel to a line drawn from the vesical neck to the orifice of the right ureter. The orifice of the left ureter was retracted. He resected the fistula and repaired the vesicovaginal fistula, suturing the vesical and vaginal walls separately. Ureteral catheters were placed in the ureters. Twelve days after this operation the patient voided normally without a drop of vaginal leakage. The anterior vaginal wall regained its elasticity and did not present any cicatricial zone.

The operation usually comprises the following steps: (1) suprapubic exposure of the bladder; (2) suprapubic cystotomy and introduction of vesical retractors; (3) resection of the fistula; (4) repair of the vaginal wall; (5) closure of the vesical wall; (6) ureteral catheterization and closure of the bladder. A sterile glass tube is introduced into the vagina up to the cervix, so as to obtain a solid base and also to fix the trigonal area. After the bladder has been opened, and the retractors have been introduced, the fistulous tract is carefully excised. The excision is followed by the separation of the bladder and vaginal walls, which are sutured separately. The ureters then are catheterized with catheters the ends of which have been cut and which are inserted to a distance of 12 cm. above the ureteral orifices. The catheters then are removed, and the bladder is closed.

Neural Lesions.—Smith and Strasberg [35] investigated 50 cases of neurogenic and cord bladder. Contrary to the common belief in urologic literature that dilatation of the ureter and renal pelvis accompanies neurogenic and cord bladder, they did not encounter a single case of dilatation of the ureter and renal pelvis. Tests of renal function applied to the group did not demonstrate any impairment of function. Forty-four of the group were patients suffering from syphilis (Wassermann reaction of the spinal fluid positive); the remaining 6 included patients who had transection or tumor of the spinal cord, tumor of the frontal lobe, epilepsy, cerebral arteritis or subarachnoid hemorrhage. Smith and Strasberg define a disturbance of the bladder as neurogenic when in the absence of any urethral obstruction the line on the graph definitely deviates from the normal, either toward a horizontal position, (an atonic bladder) or toward a vertical direction (a hypertonic bladder). A cystometrographic study was made on each patient. In the series 3 had hypertonic and the remainder either hypotonic or atonic bladders. The syphilitic patients were in the last classification, and this was subdivided further into those with early, preclinical hypotonic bladders and those with inert, atonic bladders and long-standing urinary retention, as evidenced by a flat curve. In approximately 50 per cent the residual urine amounted to from 30 cc. to almost the entire amount collected.

PROSTATE

Carcinoma.—Colston [36] made a study of the radical operations for carcinoma of the prostate performed in the Brady Urological Institute during a five year period, to determine the percentage of cases suitable for radical operation out of all cases of carcinoma of the prostate encountered in the institute.

There were 4 who died in the hospital in the series of 73 patients operated on—a mortality rate of 5.5 per cent. Of 43 patients for whom the prognosis was good, 41 are living and well without evidence of recurrence or metastasis. Of 26 patients for whom the prognosis was poor, 8 are living and well from three months to five years after operation.

Intensive follow-up of all patients who had early cancer of the prostate and on whom Young's radical operation was performed showed that more than 50 per cent were free from recurrence or metastasis from five to twenty-seven years after leaving the hospital. A study of the postoperative functional results was also carried out on the 69 patients who comprise this series. In 49 the functional result was excellent, all having complete urinary control. The result was classified as fair in 11, who noted occasional slight leakage during the day, and in 8 the result was evaluated as poor, since some form of apparatus was neces-

34. Valmé, W.: Transvesical (Suprapubic) Closure of Vesicovaginal Fistula, J. Urol. **50**:40-41 (July) 1943.

35. Smith, E., and Strasberg, A.: The Upper Urinary Tract in Cases of Neurogenic Bladder: Preliminary Communication, J. Urol. **49**:803-807 (June) 1943.

36. Colston, J. A. C.: Carcinoma of the Prostate: A Study of the Percentage of Cases Suitable for the Radical Operation, J. A. M. A. **122**:781-784 (July 17) 1943.

sary during the day and in some instances during the night.

Herbst [37] discusses histopathologic studies of prostatic carcinoma under endocrine treatment. He concludes that from the microscopic standpoint no changes occur that are characteristic of any modification of carcinoma of the prostate cells as observed with present methods of staining. This study suggests the necessity for further interest and experimentation with certain biochemical staining methods in an attempt to bring out changes, if they exist, so that they can be recognized.

Quinland [38] presents a study of 34 cases of cancer of the prostate in Negroes. The patients ranged in age from 42 to 106 years. The average age of the patients on whom operation was performed was 60 years, while the age of those on whom necropsy was performed averaged 70 years. One patient on whom prostatectomy was done for cancer underwent nephrectomy for nephrolithiasis three years and four months later and is alive and working four years and eight months after the prostatectomy. Cancerous growths ranging from microscopic inclusions to a huge mass of 720 Gm. were studied, with the disclosure that extensive and generalized metastatic growths were more frequent with the scirrhous type of carcinoma than with other types. The 18 per cent incidence in this collection is comparable to percentages reported from other clinics.

Henline,[39] in discussing carcinoma of the prostate, states that there are three general regions within the prostate which may be involved in a pathologic process and three main types of prostatic disease. It is usual for each type of pathologic change, at least during its inception, to limit itself to a particular region, but any combination of these distinct entities may coexist.

The two lateral lobes, usually referred to as the functioning prostatic glands, are the seat of prostatic infections. Bacteria may invade the deep recesses of these tortuous glands in the lateral lobes and produce acute or chronic prostatitis or a prostatic abscess, or the lobes may be the seat of endogenous prostatic calculi. According to recent investigations, the functioning portions of these lateral lobes are rarely the site of origin of either prostatic hyperplasia or cancer.

Hyperplasia of the prostate develops just beneath the urethra. Deming and Wolf in a recent study of 210 prostates showed that hyperplasia is seen first as a fibromuscular mass in the muscular wall of the prostatic urethra, which lies close to the urethra.

Carcinoma develops as a distinct pathologic process in the prostate and is not related to either infection or hyperplasia of the prostate. Carcinoma usually develops in the posterior lobe, a region rarely, if ever, affected by either infection or hyperplasia.

Carcinoma of the prostate develops in approximately 15 per cent of men past 50 years of age. The incidence increases with advancing years. When it is considered that 1 in every 7 men past 50 years of age has carcinoma of the prostate, the importance of this lesion in advancing years becomes apparent. It also becomes obvious that many prostatic cancers must progress slowly; otherwise, extensive carcinomatosis and death from prostatic carcinoma would be an even more frequent finding among elderly men than it is.

The most common site of origin of carcinoma of the prostate is the posterior lobe. This lobe is the portion of the gland posterior and posterolateral to the fan-shaped ducts which enter the sides of the urethra. The function of this lobe, if any, is unknown, and it remains dormant from birth until senile changes occur.

Detection of the presence of early carcinoma of the prostate devolves on the physician who examines patients periodically for their general health. Carcinoma may be confused with fibrosis. The age of the patient may tend to relieve one's suspicion of a malignant lesion. Fibrosis frequently is somewhat less hard than a malignant lesion. One may also confuse an early malignant lesion with prostatic calculi. The latter may be located so near the capsule that differentiation by palpation is impossible. Roentgenologic examination will aid in making the diagnosis of calculi.

When a suggestive nodule is palpated in the prostate, Henline advises a perineal exposure in order to take a specimen of the nodule for biopsy.

Henline states that "complete prostatectomy" refers to the removal of the entire prostate with its capsule and the entire prostatic urethra. Such complete removal is necessary to eradicate the disease and can be done only by the perineal approach. The line of cleavage which permits hyperplastic prostatic tissue to be enucleated

37. Herbst, W. P.: Histopathologic Studies in Prostatic Carcinoma Under Treatment by Castration, the Injection of Diethylstilbestrol or Both, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:337-343, 1942.

38. Quinland, W. S.: Cancer of the Prostate: A Clinicopathologic Study of Thirty-Four Cases in Negroes, J. Urol. **50**:228-236 (Aug.) 1943.

39. Henline, R. B.: The Diagnosis and Treatment of Early Carcinoma of the Prostate, J. A. M. A. **122**:785-789 (July 17) 1943.

suprapubically leaves behind the entire posterior lamella, from which most cancerous growths arise. Transurethral resection also removes the hyperplastic tissue but the so-called capsule, which is the posterior lamella of tissue, is of necessity left behind. Thus, if carcinoma is not found in the tissue removed either by suprapubic prostatectomy or by transurethral resection, there still is no assurance that carcinoma of the prostate is not present. Henline has had several patients who sought relief after each of these operations because of carcinoma of the prostate in the portion of the gland left behind.

Sarcoma.—Melicow, Pelton and Fish [40] reported 4 cases of sarcoma of the prostate: 2 of fibrosarcoma, the patients being aged 34 and 18 years; 1 of rhabdomyosarcoma, the patient being aged 16 years, and 1 of reticulum cell sarcoma.

The symptoms were as follows: In case 1 (spindle cell fibrosarcoma) there were acute retention, rectal tenesmus and presence of a suprapubic mass. The prostate was large, firm, cystic in areas but not tender. In case 2 (pleomorphic fibrosarcoma) there were chills and fever, acute retention, lumbar pain on the left side and loss of weight. The prostate was markedly enlarged, symmetric, boggy and tender. In case 3 (rhabdomyosarcoma) there were perineal pain and acute retention. The prostate was enlarged, smooth, partially fixed but not hard. In case 4 (reticulum cell sarcoma) there were frequency of urination, nocturia and acute retention. The left lobe of the prostate was enlarged, soft and boggy but not tender.

The patients all died. In case 1 (spindle cell fibrosarcoma) death occurred eight months after onset of symptoms and seven months after operation and radiotherapy. In case 2 (pleomorphic fibrosarcoma) death occurred two months after onset of symptoms and five weeks after operation and radiotherapy. In case 3 (rhabdomyosarcoma) death occurred one year after onset of symptoms and two months after the first operation and implantation of radon seeds. In case 4 (reticulum cell sarcoma) death occurred six months after onset of symptoms and four months after the first operation and radiotherapy.

A review of the literature shows the following facts: 1. Sarcoma of the prostate is rare. Its incidence was approximately 1 in 1,000 prostates removed for "benign hypertrophy" or for carcinoma. 2. About 200 cases of sarcoma of the prostate have been reported to date. 3. While sarcoma of the prostate tends to be a disease of youth and carcinoma a disease of later decades, nevertheless in rare instances carcinoma (usually one of the anaplastic types) does occur earlier than the fourth decade; and sarcoma (usually leiomyosarcoma or lymphosarcoma) may occur sometimes in the fifth to eighth decades. 4. Sarcoma of the prostate develops insidiously and painlessly but soon grows rapidly, breaking all barriers and causing obstruction. Operative procedures, except for the removal of obstruction, even accelerate the process; radiotherapy often gives relief.

Resection.—Emmett [41] states that it has been demonstrated that transurethral resection properly done can care for any and all types of obstruction of the vesical neck and that the functional results will be as good as, or better than, those produced by open types of operation.

Various instruments have been designed in the past for transurethral resection. One by one they gradually have been discarded until today two chief types remain in use. These are (1) the wire loop, activated with a high frequency cutting type of electric current and associated with a foroblique telescopic lens system, and (2) the cold punch instrument, which cuts with a cold tubular knife and does not have any telescopic equipment. Adequate and satisfactory operations can be done with either of these instruments if the surgeon is trained sufficiently in their use. Each instrument has its advantages and its disadvantages. The McCarthy resectoscope with its telescopic lens system furnishes a larger field of vision than the cold punch instrument and supplies moderate magnification of the operative field. The cold punch, on the other hand, allows only a relatively small field of vision, so that the instrument must be rotated through an arc of 360 degrees if one is to visualize the entire circumference of the prostatic urethra. To men trained in this type of direct cystoscopy, however, the limitation described does not present any particular problem, and any disadvantage is offset by the fact that in the presence of sharp bleeding the view is much clearer than that obtained with a lens instrument.

Experience at the Mayo Clinic with a large number of resections indicates that low spinal anesthesia is the anesthesia of choice. Procaine hydrochloride is used in doses of 70 to 90 mg. dissolved in 2 cc. of spinal fluid and is injected through the third or the fourth lumbar interspace. This yields sufficient anesthesia in the

40. Melicow, M. M.; Pelton, T. H., and Fish, G. W.: Sarcoma of the Prostate Gland: Review of Literature; Table of Classification; Report of Four Cases, J. Urol. **49**:675-707 (May) 1943.

41. Emmett, J. L.: Transurethral Resection with the Cold Punch: Operative Technique, J. Urol. **49**:815-839 (June) 1943.

region of the prostate for at least sixty minutes, which is the maximal length of time any resection should take. Resection of small amounts of tissue or secondary resection often can be done while the patient is under intravenous anesthesia. At the Mayo Clinic the use of transsacral and caudal anesthesia has been discontinued in these cases because priapism and occasionally systemic reactions from the rather generous amount of procaine hydrochloride employed have been annoying.

The remainder of Emmett's paper is limited to a consideration of the technic employed in transurethral prostatic resection with the cold punch.

Ninety per cent of all difficulty encountered in passing instruments through the male urethra which is not the site of a stricture is encountered at the apex of the prostate. When this organ is enlarged by a benign or a malignant growth, the chance of difficulty in this region is increased many-fold. To avoid errors of direction while introducing the resectoscope, one must be extremely gentle and slow in one's manipulative motions. A finger introduced into the rectum as a guide often will allow the surgeon to appreciate the situation. A Van Buren sound carefully introduced may pass when a resectoscope will not, as the curve of the sound more closely simulates that of the urethra.

The actual mechanics of cutting tissue with the cold punch is quite simple, although there are a few refinements of technic which are helpful to know. With the tubular knife in the closed position and the water inlet open, one observes the portion of tissue to be cut. The knife blade is then opened its entire distance (unless for some reason a shorter bite is desired) and the resectoscope is advanced sufficiently to allow the tissue to enter the fenestra. An attempt is made to fill the lumen of the resectoscope almost completely with the tissue so that the piece of tissue cut will be of generous size. The knife is then thrust forward, cutting off the piece of tissue. When the knife is opened again, the piece of tissue will be dislodged and in most cases will fall free into the bladder.

An adequate supply of sterile water is essential in transurethral resection. The source of water should be sufficiently high to allow the water to flow rapidly and adequately through the resectoscope, keeping it free of blood, so as to allow clear vision.

Many of the complications that follow transurethral resection can be attributed directly or indirectly to excessive loss of blood. For this reason it is imperative that hemostasis be maintained as perfectly as possible. With the activated loop type of resection, some hemostasis is secured with each cut. With the cold punch, each cut is made with a cold knife, and hemostasis must be secured subsequently by fulguration of individual bleeding points with the fulgurating electrode. Loss of blood may occur during operation and after operation. The periods are equally important. A good rule to follow is to control the bleeding fairly well in any region before proceeding to another.

It is a fairly common experience for the surgeon to note in the course of a resection that the wash water contains a large amount of blood and yet not be able to see where the blood is coming from. The bleeding eventually will be found to be coming from one or two large hidden spurting vessels. They are hidden usually by a piece of tissue which is situated near the apex. The most common site for these poorly visualized bleeding points is in the anterior sector near the apex. A small "roll" of adenomatous tissue situated adjacent to the external sphincter may obscure the origin of the bleeding vessel completely. Whenever such a situation is encountered, the surgeon should remove the obstructing tissue at the apex quickly so that he has an unobstructed view of the entire region of resection.

The secret of good hemostasis in general surgical practice is adequate exposure. This is equally true in transurethral operations. There is nothing more difficult than to secure adequate hemostasis in an irregular, incompletely resected prostatic urethra in which there are alternate projections and depressions. Adequate exposure of the walls of the prostatic urethra, leaving a smooth, uninterrupted surface, permits complete and accurate visualization of all bleeding vessels.

Control of arterial bleeding usually does not present any difficulty. The same may be said of bleeding from small or moderate-sized veins. There is usually no difficulty in identifying the location of these veins unless there is some mechanical interference, such as remaining nodules of tissue, that obstructs the surgeon's view. This is not true, however, in the case of bleeding from large veins and venous plexuses. This type of bleeding is encountered when the resection is carried a little too deeply into the prostatic "capsule" or when the trigone is elevated or the muscle fibers at the vesical neck are incised too deeply. No "spurting" vessel is seen. There is rather a "welling up" of dark venous blood from a more or less deep cavity. In many such cases persistent fulguration tends only to enlarge the cavity and increase the hemorrhage. Another variety of severe venous bleed-

ing occurs in cases in which it appears as though definite coarse fibers of the prostatic "capsule" have been exposed and a "sheet" type of bleeding occurs from between them.

If the posterior vesical lip has been cut so deeply that the trigone is separated from the vesical neck or becomes elevated, severe venous bleeding may occur from underneath the trigone. When one is examining this region, pressure with the heel of the resectoscope may tend to stop the bleeding so that the surgeon is unable to determine its source. Pressure of the resectoscope as one moves the instrument from place to place for observation may be sufficient to stop the flow of blood so that it is overlooked easily. This is especially true if the site of bleeding is near the apex, where the prostatic urethra is narrow. Here the slightest movement of the resectoscope to visualize a region may produce sufficient pressure to stop the bleeding temporarily. In such a case the bladder should be emptied completely and the resectoscope should be withdrawn to the distal border of the verumontanum; then the instrument should be kept in the midline and should not be moved from one side to the other, and the water should be allowed to run through the resectoscope very slowly. In this position the resectoscope may be rotated through an arc of 180 degrees. Usually, this maneuver will permit the surgeon to identify the site of the bleeding.

After a reasonable amount of fulguration has failed to control this type of bleeding, one should use a hemostatic bag catheter with or without tension. It goes without saying that if pressure can be exerted in the proper place the hemorrhage can be stopped. If the prostatic cavity is small and the bleeding is near the apex, a bag catheter distended with about 30 cc. of fluid and pulled well down into the prostatic cavity should control the bleeding. If the prostatic urethra is large or if the bleeding is near the vesical neck, a larger bag, such as the pear-shaped Bardex bag, may be required. This bag may be distended with 120 cc. or more of fluid. The bag often will fit well enough into the prostatic capsule to control the bleeding. At other times a moderate amount of traction may be necessary.

It must be remembered that a bag catheter will not control arterial bleeding. It is of value only in the presence of venous hemorrhage. In the absence of arterial bleeding a failure of the bag to control venous hemorrhage means that adequate pressure is not being obtained. In subtrigonal bleeding, for instance, owing to the laxity of the base of the bladder, no amount of pressure of a bag in the vesical neck may be effective unless counterpressure can be applied against the base of the bladder.

The ease with which the patient may be cared for after resection depends chiefly on how perfectly hemostasis was obtained at the conclusion of the operation. The chief problem is to keep the catheter draining well in order that the bladder may be kept free of clots by lavage.

If the bladder becomes filled with clots and the catheter becomes obstructed, or if the bleeding continues to be too profuse, one should never hesitate to return the patient to the operating room to evacuate the clots and fulgurate the bleeding vessels. Pentothal sodium is usually the anesthetic of choice for such a procedure. No matter how full of clots a bladder may become, it should never be necessary to perform suprapubic cystostomy to evacuate them. The no. 28 F. direct vision cystoscope or the resectoscope is inserted into the bladder, and the clots are aspirated by means of the suction syringe. After each aspiration a moderate amount of water is allowed to enter the bladder to furnish sufficient fluid to wash out the clots. Clots often tend to collect in the dome of the bladder and around the anterior half of the vesical neck. To remove such clots the resectoscope should be rotated so that the heel of the instrument is situated anteriorly. The ocular end of the resectoscope is then depressed so that the heel of the instrument is in the mass of clots. Aspiration with the suction syringe will then remove almost all of the clots.

Mercier [42] describes the evolution of his ideas on the indications for transurethral resection of the prostate. Of the first 25 patients, 8 died; between the twenty-sixth and the one hundred and fiftieth patient 9 died; between the one hundred and fiftieth and the three hundredth 8 did not survive; between the three hundredth and the five hundredth 5 patients were lost, and in the last series, from the five hundredth to the nine hundredth, 3 died, a rate of 0.7 per cent.

Mercier uses McCarthy's resectoscope in conjunction with Wappler's cutting machine. In his opinion, all instruments are good; the solution lies in the skilful handling of one or the other. With McCarthy's, he is able to remove the hypertrophic tissue as far as the capsule without being obliged to insert the finger in the rectum so as to elevate the tumor and apply Stern's modified apparatus.

Spinal anesthesia was applied in 491 cases; patients were given cyclopropane with Connell's

42. Mercier, O.: End Results of Nine Hundred Cases of Transurethral Resection of the Prostate, J. Urol. 49:665-668 (May) 1943.

closed apparatus in 402. As regards the latter, in Mercier's opinion, there was little danger of explosion: he had installed a ground wire, and the anesthetist took great care to control any gas leak. Seven patients who had "grade A" prostates were anesthetized with pentothal sodium.

Mercier states that the tendency of beginners is to overcoagulate, both as to area and as to depth, in order to avoid hemorrhages in the course of the operation. If coagulation is excessive, grave secondary hemorrhages may happen about the tenth or twelfth day after the resection; moreover, elimination of coagulated tissues will impede recovery. Mercier coagulates superficially at the precise point where an artery bleeds, and he avoids coagulation of veins except when there is considerable hemorrhage. After a trial of compression catheters, they were abandoned, because they are useless if coagulation has been obtained properly and also because they frequently cause painful vesical tenesmus. He uses Marion's rubber catheter, which furnishes the advantage of multiple outlets. He lets it remain for three days, but in cases in which fever runs high, he does not remove it until the temperature has fallen to normal. On the day following the operation, he prescribes sulfonamide medication. This clarifies the urine and brings it back to normal within a period that varies between fifteen days and eight weeks. The same results are obtained in pollakiuria.

The quantity of tissue taken out in these 900 cases varied between 2 and 182 Gm. The length of time that it took to perform transurethral resection stretched from three to sixty-five minutes, the latter in the case in which tissue weighing 182 Gm. was resected. In all of these cases Mercier never had recourse to a two stage operation but removed in one session the quantity of tissue deemed necessary. In 11 instances he used transurethral resection after cystotomy, but since then he has abandoned this practice.

One hundred and twenty-four patients (13.8 per cent of the 900) presented carcinoma of the prostate. The 776 remaining patients presented benign hypertrophy of the prostate. Four hundred and eighty-two patients answered a questionnaire. Of these 482 patients 9 had to undergo a second operation. Four of them, on whom a first operation had been performed in 1934, underwent a second operation in 1936. Two underwent a first operation in 1936, 1 in 1937 and 2 in 1939; a second operation was performed on each of these 5 patients in the course of the same year, respectively. The probable cause of each of these reiterations seems to have been that not enough tissue was removed in the first instance.

In these 482 cases pollakiuria and urinary pains never lasted more than eight weeks, and in 296 of the cases these troubles had disappeared within the month following the operation. Finally 182 patients retained pollakiuria, which returns once in the latter part of the night.

Davis [43] states that during the past decade there has been an extraordinary change in the attitude and opinion of members of both the laity and the medical profession with respect to prostatic surgery. The factors responsible for this may be enumerated as follows: (1) the gradual recognition that the tradition that prostatectomy is a hazardous ordeal is fallacious; (2) the development and more frequent use of transurethral prostatic resection; (3) articles on genitourinary subjects in popular lay magazines; (4) syndicated newspaper articles by reputable medical columnists; (5) ethical "public enlightenment" programs, sponsored by medical societies; (6) "protect your health" magazine advertisements sponsored by life insurance companies; (7) persistent blatant radio advertisement by utterly unscrupulous charlatans; (8) the introduction of the sulfonamide group of antiseptics of the urinary tract, and (9) what may be termed the modern tendency toward lay enlightenment.

For these reasons the urologic surgeon now sees a much larger percentage than he did formerly of patients for whom the risk of operation is low, permitting safe prostatic operations without preliminary drainage. However, even with this increase surgeons are not seeing a great many such patients.

Osteomyelitis Complicating Prostatic Operations.—Deming and Zaff [44] discuss metastatic vertebral osteomyelitis complicating prostatic operations and report 3 cases which illustrate a definite relation between infection of the urinary tract and acute vertebral osteomyelitis.

In a series of 1,500 cases of pyogenic osteomyelitis, it was found that the spinal column was involved in 3.94 per cent. Acute pyogenic spinal osteomyelitis is infrequent among persons of the ages at which involvement of the prostate is common. The average age for osteomyelitis of the spinal column is 31 years. Men are affected twice as often as women. The location of spinal osteomyelitis was coccygeal in 3 of 102 cases, sacral in 9, cervical in 8, thoracic in 31 and lumbar in 51. In another series of 71 reported cases, the location was sacral in 9, cervical in 12,

43. Davis, E., in discussion on Mercier,[42] p. 672.

44. Deming, C. L., and Zaff, F.: Metastatic Vertebral Osteomyelitis Complicating Prostatic Surgery, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:287-305, 1943.

thoracic in 19 and lumbar in 31. Thus, there is a predilection in the lumbar region for this lesion.

The symptom complex of acute osteomyelitis of the spinal column is clinically dramatic. It is characterized by rigors, high fever, prostration, delirium, abdominal distention and diarrhea. Marked leukocytosis is usually present. The local pain and the neurologic manifestations frequently suggest the site of the lesion. Blood cultures are frequently positive. Many reports of cases of acute osteomyelitis of the spinal column contain a reference to the high percentage of cases in which there is infection of the urinary tract. Carson reports 4 cases of acute osteomyelitis of the spinal column and states that there were two factors common to all: Staphylococcus aureus septicemia and infection of the urinary tract. The general symptoms may be acute or subacute, and some days may elapse before local signs appear. Movement usually causes pain. In 3 cases presented by Deming and Zaff, pain in the back occurred on the fourth and fifth postoperative days, respectively, in the first 2 cases and on the eighth postoperative day in the third case. The mortality rate in cases of acute spinal osteomyelitis varies from 25 to 71 per cent.

The essential diagnostic features of the cases presented were narrowing of the intervertebral spaces, irregular destruction of adjacent portions of the vertebral bodies, varying degrees of sclerosis of the participating vertebrae and rapid proliferative periosteal formation of new bone. The presence of an associated paravertebral shadow of soft tissue tends to confirm the diagnosis. These findings coincide with the accepted roentgenologic appearance of pyogenic osteomyelitis of the spinal column.

The invasion producing acute pyogenic osteomyelitis of the vertebrae has been recognized as (1) direct and (2) hematogenous. In only 3.94 per cent of 1,500 cases of acute pyogenic osteomyelitis did lesions of the spinal column develop, so that infection does not spread through the blood stream from one bony lesion to another often. Infection of the blood stream is common, but acute vertebral osteomyelitis is rare. The so-called typhoid spine and gonococcic arthritis of the spinal column have been explained on a blood-borne basis. Many patients suffering from typhoid have infection of the urinary tract.

In all 3 of the cases of prostatic resection presented, acute spinal osteomyelitis developed following operation. In 2 of the cases the classic two stage suprapubic operation, and in the third, transurethral resection, was performed. There was nothing in the histories to indicate that such a complication as metastatic vertebral osteomyelitis should be expected. All 3 patients showed certain postoperative symptoms in common: The immediate convalescence was usually stormy and severe. All had chills and "spiking" temperatures in spite of the administration of urinary antiseptics and the large intake of fluid. All 3 patients suffered from weakness or prostration, perspiration, abdominal distention, hiccup, restlessness and irritability.

The early treatment of the severe backache in the 3 patients could have been improved if the correct diagnosis had become apparent. However, conservative therapy was naturally applied. Roentgen therapy, given in the first case, did not give a satisfactory result. In the second case, rest and the wearing of a back brace were prescribed, with a satisfactory result, after the exact diagnosis had been made. Surgical exploration clarified the diagnosis in the third case, but the disease was too far advanced for recovery to be expected. Patients who have undergone prostatic resection and who complain of severe backache complicating their convalescence should be suspected of having early vertebral osteomyelitis, and treatment should be instituted to prevent extension of the pathologic process, to shorten the period of convalescence and to diminish the mortality rate. Any infection of the urinary tract represents a potential factor for the development of metastatic vertebral osteomyelitis.

Kretschmer,[45] in discussing the article of Deming and Zaff on metastatic vertebral osteomyelitis complicating prostatectomy, states that he has seen 3 patients who had metastatic osteomyelitis of the spinal column. The first patient was a man who had a single kidney and who was operated on for a stone in the ureter, which was removed successfully. Several months prior to this operation, he had had nephrectomy for pyonephritis. Following the removal of the stone, severe pain developed in the back, and a low grade fever was noted. Physical examination disclosed interference with the function of the spinal column in that it was impossible for the patient to flex it. A roentgenogram showed osteomyelitis. This healed with rest in bed.

The second patient was a man who had been operated on four weeks before he came to Kretschmer. The diagnosis made prior to operation was perirenal abscess. At operation no perirenal abscess was found. The patient complained of pain in the back, a low grade fever and leukocytosis. He, too, was unable to flex

45. Kretschmer, H. L., in discussion on papers by Cahill, Melicow and Guerry,[56] Kretschmer, Deming and Zaff,[44] McCague[29] and Paine, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**:320-321, 1943.

his spinal column. A roentgenogram disclosed vertebral osteomyelitis. Rest in bed and appropriate orthopedic treatment with splints and braces resulted in a complete cure.

In the third case metastatic vertebral osteomyelitis developed following prostatectomy.

Kretschmer expressed the opinion that in the cases just cited the infection was metastatic.

URETHRAL DIVERTICULUM

Higgins and Roen [46] state that urethral diverticulum is rather uncommon among women, although exact statistics as to its frequency are not available. At the Mayo Clinic 19 cases were encountered in a ten year period. At the Cleveland Clinic only 7 cases, including the one reported by Higgins and Roen, have been observed in the twenty-two years since 1921.

Urethral diverticulum may be defined as a pouch formed by dilation of a portion of the urethrovaginal septum and communicating with the urethral canal. The pouch may communicate widely with the urethra, or it may have a narrow or tubular opening into it.

It is quite likely that the true congenital diverticulum of the urethra more often presents features that simulate cystocele than do those sacs which arise secondarily. There are two principal causes of the acquired type: 1. Trauma may produce a weakened point in the urethral wall, and herniation may later occur through this region. Trauma may be in the form of passage of a calculus, instrumentation or childbirth. Undoubtedly, the last is the most frequent causative factor. Instrumentation is not so often the cause in the female urethra as in the longer pendulous urethra of the male sex. 2. An inflammatory process in the periurethral tissues may serve to produce a diverticulum. Inflammatory occlusion of a urethral duct may produce a retention cyst of the associated gland, and subsequent suppuration and rupture into the urethral lumen may serve by repetition to produce an increasingly larger sac.

The symptoms of urethral diverticulum with or without calculus are those of infection of the lower part of the urinary tract, including frequency and dysuria, nocturia, pyuria and rarely hematuria, and in instances in which the calculus is large, urethral obstruction may occur. Local examination reveals a smooth spherical visible and palpable swelling of the anterior vaginal wall just posterior to the external urethral meatus. This must not be confused with cystocele. If a calculus is present, this swelling is hard. Urethroscopic inspection and roentgenographic examination, especially if a cystogram has been made with a urethral catheter in place, confirm the diagnosis.

The treatment of urethral diverticulum with or without stone is entirely surgical. The sac of the diverticulum is approached readily through incision in the anterior vaginal wall. Resection of the sac with resuture of the urethral and vaginal walls has given universally satisfactory results. Diversion of the urinary stream for approximately a week is a necessary feature of the treatment. In most cases this may be accomplished by an inlying catheter; rarely, suprapubic cystotomy may be required. In all reported cases the wall has healed promptly without the formation of a urethrovaginal fistula.

Higgins and Roen report the case of a woman aged 66 years, who complained of dysuria, frequency, difficulty in voiding and slight terminal hematuria. The past history was irrelevant except for the fact that some three to four years previously she had experienced a severe attack of "cystitis" which had subsided in a month's time. The present urinary symptoms had appeared about eight months prior to her visit to the clinic. The symptoms had been progressive, especially the difficulty in voiding.

Physical examination revealed a somewhat obese elderly woman who did not show any abnormality except for a bulging hard mass in the anterior vaginal wall. This was diagnosed clinically as a calculus within a diverticulum of the urethra.

Roentgenologic study disclosed a large calculus below the level of the bladder. The urogram indicated that the upper part of the urinary tract was normal. Urinalysis revealed a number of white blood cells and red blood cells. Culture of the urine showed Bacillus coli.

At operation the anterior vaginal wall was incised longitudinally; the diverticular sac was opened and the calculus extracted. The sac was then excised and the orifice into the urethra closed by a purse string suture. This orifice was quite narrow with a diameter of approximately 5 mm. The vaginal wall was sutured. A catheter was left indwelling for six days after operation. The wound healed by primary intention, and the patient returned home eleven days after operation, free of symptoms.

The calculus was large, measuring 3.9 by 2.6 by 2.5 cm., and was smooth, hard and laminated, with a soft center. Chemical analysis showed it to be composed of calcium, phosphates, carbonates and a trace of ammonia.

46. Higgins, C. C., and Roen, P. R.: Calculus-Containing Urethral Diverticulum in a Woman: Report of a Case, J. Urol. **49**:715-719 (May) 1943.

TESTICLE

Prosthesis.—Rea [47] reports a case in which an artificial testicle made out of lucite (polymerized methyl methecrylate) was implanted in the scrotum of a boy 13 years of age who was believed to have congenital anorchidism. The cosmetic and psychic results of the operation justified the procedure. Lucite spheres have been implanted in the scrotum also in a case of orchidectomy for a malignant tumor of the testis and also in 2 cases of castration for carcinoma of the prostate. A note is made concerning the size of testes at different ages, and some impressions concerning the size of artificial testicular implants are recorded.

Polyorchidism.—Thiessen [48] states that the presence of more than two testes in man is a rare occurrence. In the older literature there are numerous, almost mythologic references to warriors and lovers who were thus endowed. Few proved cases have been reported. Thiessen adds 1 more proved case to the literature.

The patient, who was 25 years of age, complained of a pain in the right inguinal region. Twelve years before, following trauma, the right testicle, which had been normal in size, decreased somewhat. The left testicle was normal. Shortly after this, right inguinal hernia developed. The results of general examination were negative except for relaxed bilateral external inguinal rings. The right testicle was atrophic. Surgical repair of the hernia was advised. At the time of operation the right side was explored first. A thickened cordlike structure was felt separate from the spermatic cord and the vessels. The upper end continued retroperitoneally to a rounded mass resembling a testicle. The scrotal testicle was found and delivered into the incision. Its vessels and cord were separate from those of the intra-abdominal organ. The smaller, upper testicle was removed. Microscopic examination showed testicular tissue.

EPIDIDYMIS

Blastomycosis.—Jacobson and Dockerty [49] describe the clinical and pathologic features of 4 cases of systemic blastomycosis involving the epididymis. Epididymitis was the most common genitourinary manifestation of blastomycosis; in the series of cases of generalized blastomycosis observed by Jacobson and Dockerty the incidence was 33 per cent. Clinically the condition simulated tuberculosis. A primary pulmonary focus was established definitely in 1 case, and such a focus was believed to be present in 2 additional cases. In the remaining case evidence of intrathoracic disease was not obtained at necropsy. Treatment with iodides and irradiation apparently was successful in 2 patients, who survived for two and ten years, respectively. One of these patients had undergone epididymectomy, which apparently hastened recovery. In 2 patients the disease proceeded to a fatal outcome, with involvement of the genital structures in the terminal stages of the disease.

Tumor.—Evans [50] describes a group of tumors, benign in character and of characteristic histologic structure, located in direct relationship to the tunica vaginalis testis and the epididymis, including 5 personally observed and a larger number assembled from the literature. It is concluded that the tumors of this group probably are derived histogenetically from the mesothelial cells of the serosa of the tunica vaginalis and may properly be denominated mesotheliomas.

AVULSION OF SCROTUM

Byars [51] reports 3 cases of avulsion of the scrotum and of the skin of the penis. In each instance avulsion was the result of loose clothing being caught in rapidly moving machinery. Such defects of the genitalia are rather rare.

The scrotal flap with pedicle supplies the most desirable tissue for covering a penile defect because of the elasticity of the transplanted skin. This is especially true when there has been damage to the corpora cavernosa with deep scarring and contraction. In many of these cases scrotal tissue is not available since it also has been lost. Even under ideal circumstances the scrotal tissue may be inadequate in amount for complete coverage of the penis. A third point to be considered is that a wound of the penis which has contracted may undergo further contraction during the period of attachment of the penis to the scrotal flap. Pedicled flaps from other portions of the body are too thick and lack the desired elasticity.

Thick split skin grafts seem to answer most nearly the needs in the average case. If possible, it is oftentimes desirable to use a combination of scrotal flap and free skin graft, especially to prevent possible scar constriction about the base

47. Rea, C. E.: The Use of a Testicular Prosthesis Made of Lucite, with a Note Concerning the Size of the Testis at Different Ages, J. Urol. **49**:727-731 (May) 1943.

48. Thiessen, N. W.: Polyorchidism—Report of a Case, J. Urol. **49**:710-714 (May) 1943.

49. Jacobson, C. E., Jr., and Dockerty, M. B.: Blastomycosis of the Epididymis: Report of Four Cases, J. Urol. **50**:237-248 (Aug.) 1943.

50. Evans, N.: Mesothelioma of the Epididymis and Tunica Vaginalis, J. Urol. **50**:249-254 (Aug.) 1943.

51. Byars, L. T.: Avulsion of Scrotum and Skin of Penis, Surg., Gynec. & Obst. **77**:326-329 (Sept.) 1943.

of the penis. The difficulty of "take" in this area makes the free full thickness graft less desirable than the split skin graft. The disadvantages of the free skin graft are that the skin is not as expansile as is normal penile skin and that the grafts tend to contract for a period after their application. Both of these difficulties may be largely overcome by the transplantation of an adequate amount of skin. This is done by making the wound the maximal size at the time of application of the graft and by supplementing the graft if necessary at a second operation.

In the preoperative preparation of an ulcerated wound, all surrounding hair should be kept shaved, the area should be cleansed frequently by the use of soap and water and sulfanilamide or sulfathiazole powder should be dusted on the surfaces one or more times daily. The patient sits in a saline bath for several hours daily if possible. When the granulations have become compact and uniformly red, and there is a minimum of discharge on the dressings, and the appearance of the wound has ceased to improve, the wound is ready for grafting.

At the time of repair, all granulation tissue is trimmed away with a sharp knife, and the deeper scar is dissected away carefully until the penis is completely elongated and freed from the contraction which has resulted from partial healing. All bleeding points are ligated carefully with the finest available silk. If there is any normal skin left on the penis, either about its base or about the glans, this skin is retracted. A collar of skin about the base of the penis can be sutured back as a roll at its junction with the abdominal wall. A collar of skin about its attachment to the glans can be drawn toward the tip of the penis.

For a split skin graft, approximately two thirds of the thickness of the skin is taken. If it is possible to get one piece large enough to cover the entire wound, this is done. A catheter is inserted into the bladder, and the penis is held completely extended. The graft is draped over the wound and sutured accurately to the borders of the wound proximally and distally, with interrupted sutures.

The first postoperative dressing of the wound is done on the fourth or the fifth day after operation. A dressing as nearly like the original as possible is reapplied. After the seventh or eighth postoperative day the catheter is removed. A similar but less bulky dressing is applied and is held in place with an athletic supporter. Split skin grafts undergo a period of contraction during the first two months. Following this, they begin to soften and relax.

Byars presents these cases with the idea of expressing the desirability of primary repair rather than subjecting the patient to the prolonged discomfort coincidental with secondary repair. In addition, he feels that grafting of skin to properly prepared open wounds resulting from avulsion of tissue is practical and should be considered even though a number of hours have elapsed since the injury.

In none of Byars' 3 cases was restoration of the scrotum attempted. It is obvious that under some circumstances such a reconstruction might be considered essential. If it is contemplated, the testicles should be planted under the skin and the subcutaneous tissue of the upper inner parts of the thighs at the time of the initial repair. After the defect of the penis has been repaired adequately and has healed, each testicle and its cord would be dissected free from the thigh, carrying with it the overlying skin and fat. The tissue from the right and the left thigh then would be sutured together in the midline, the testicles with their overlying skin and fat being joined to make the two halves of the reconstructed scrotum. This would occupy approximately the normal position and probably would maintain nearly the optimal temperature of these organs. This reconstructed scrotum would not be contractile. The two donor sites on the inner surfaces of the thighs would be covered with split skin grafts.

SPERMATIC CORD

Tumor.—Zide [52] states that the occurrence of tumor of the spermatic cord is relatively rare in comparison with tumors of other structures of the body. In 1939 Schulte reported 247 cases of tumor of the spermatic cord. Since that report 10 additional cases, including the case reported now by Zide, have been compiled, bringing the total to 257 cases. Classifying these cases further, he notes that the most common types of tumor were lipoma, sarcoma, fibroma, mesodermal tumor, dermoid and angioma in decreasing order of frequency. Only 4 cases of hemangioma have been reported hitherto. Zide reports the fifth case of hemangioma of the spermatic cord. This case is of interest because of the rarity of the tumor and the problem of differential diagnosis.

A man aged 27 years had had a tumor in the right side of the scrotum for sixteen years. The mass was tender to palpation and ached on exertion. On examination the scrotum was enlarged slightly at the right upper portion. There was a lobulated mass, 2 by 3 cm. in diameter, just above the right testis. It did not transilluminate, and there was no noticeable change of size when the patient reclined. The tumor was excised through an incision in the upper right area of the

52. Zide, H. A.: Tumors of the Spermatic Cord: Report of a Hemangioma, J. Urol. **50**:255-257 (Aug.) 1943.

scrotum, approximately 1 cm. of the spermatic veins above and below its boundaries being removed. The diagnosis was hemangioma of the spermatic cord.

INFECTIONS OF THE URINARY TRACT

Discussing infections of the urinary tract, Cook [53] states that since the development of sulfonamide compounds with their known efficacy in combating infections of the urinary tract, many physicians have prescribed these drugs without sufficient knowledge of the infectious bacteria in the given case, without knowledge of the true pathologic changes and without proper respect for the various toxic manifestations which may develop in the patient.

Complete bacteriologic studies are not necessary in each case by any means. A simple Gram stain of the urinary sediment, which is at the disposal of any surgeon, will usually suffice and lead to the proper management of the patient. Cultures are helpful but are not always necessary.

Many patients may be cured of their illness with chemotherapy, as their difficulty is superficial. However, if after one or two courses of medication the desired results are not obtained, the patient is entitled to a detailed urologic investigation. The percentage of cures in cases of infection of the urinary tract falls sharply when one passes from uncomplicated to complicated infections.

When considering the drugs themselves, one should not lose sight of the value of mandelic acid. It should not be used in cases of impaired renal function, as in such cases it is toxic to the kidney. Concerning the sulfonamide compounds, there is a definite need for continued and close observation while the patient is taking the drug.

If everything possible is to be secured from chemotherapy in infections of the urinary tract, a close check on each patient must be kept. Doses should not be excessive. Repeatedly it has been demonstrated experimentally that small concentrations of any of these drugs will sterilize the urine. This has been borne out clinically. Seldom, if ever, will increased doses do more than will the usual small doses.

URINARY CALCULI

Lassen [54] states that there are two main groups of causes in the genesis of urinary calculi. One group, which undoubtedly is the more rare of the two, is that in which disease processes within or outside the urinary tract operate to supply the conditions requisite for the formation of calculi. The other group of causes, which is the more important group by far, consists largely in dietary insufficiency. Both these two groups of causes, which, as has been demonstrated, consist of a large number of various factors, can bring about changes in the saturation of the urine and, as a consequence, nuclei for the formation of calculi arise. Even though the original pathologic condition which caused these retained nuclei does not remain active, the nuclei themselves may continue to grow despite the fact that the urine is absolutely normal.

Sauer and Neter [55] report that favorable results obtained by the use of a citric acid–magnesium oxide–sodium carbonate solution (solution G, arrived at by Suby, Suby and Albright [26b]; Suby and Albright [26c]) in the treatment of patients who had late radium reactions, complicated by formation of incrustations, stimulated in vitro experiments on the antimicrobial action of this solution.

Solution G produced bactericidal effects within twenty-four to seventy-two hours at 37 C. against strains of Escherichia coli, Proteus vulgaris, Proteus morgani and Streptococcus faecalis (enterococcus).

Young cultures of E. coli (four and ten hours old) were more susceptible to the bactericidal action of this solution than twenty-four hour cultures.

Admixture of urine in appreciable amounts to solution G caused increase of p_H and decrease of bactericidal activity against Escherichia coli.

Solution G exerted approximately the same bactericidal effects against E. coli as a citric acid-disodium phosphate buffer solution of identical p_H (4.0).

Solution G is made as follows:

Citric acid (monohydrous)	32.3 Gm.
Magnesium oxide (anhydrous)	3.8 Gm.
Sodium carbonate (anyhdrous)	4.4 Gm.
Distilled water in sufficient quantity to make	1,000.0 cc.

THE RENAL LESIONS IN VON HIPPEL-LINDAU DISEASE

Cahill, Melicow and Guerry [56] discuss the renal lesions in von Hippel-Lindau disease and report a case.

Angiomatosis retinae was described first by von Hippel. Hemangioblastomas have been reported by various observers to occur associated

53. Cook, E. N.: Infections of the Urinary Tract, editorial, Surg., Gynec. & Obst. **77**:330-331 (Sept.) 1943.

54. Lassen, H. K.: The Formation of Urinary Calculi, J. Urol. **50**:110-120 (July) 1943.

55. Sauer, H. R., and Neter, E.: The Bactericidal Action of the Stone Dissolving Agent "Solution G," J. Urol. **50**:191-196 (Aug.) 1943.

56. Cahill, G. F.; Melicow, M. M., and Guerry, D., III: The Renal Lesions in von Hippel-Lindau's Disease, Tr. Am. A. Genito-Urin. Surgeons (1942) **35**: 271-281, 1943.

with other lesions of the central nervous system. Lindau was the first to recognize that a generalized form of hemangioblastoma occurs, in which not only tumor of the retina may be observed but cysts of various viscera, with cystadenoma of the pancreas and hypernephroma of the kidney.

Lindau reported that hypernephroma was present in 6 of his 15 cases. Since it occurred in the case of Davidson and his associates, in that of Wolf and Wilens and also in the present case, the proportion has been increased to 9 of 18 cases, or 50 per cent.

The case reported by Cahill, Melicow and Guerry is of interest in that the patient showed the hormonal deficiency changes thought to be due to involvement of the pituitary gland. She did not have any demonstrable pancreatic cysts. Her large renal tumor was recognized and removed and was found to be a hemangioblastoma.

The patient was a white woman, aged 26 years, who complained that her vision had been failing for eighteen months. There had been no urinary symptoms of any character. At no time had hematuria occurred. For a number of months previous to admission she had had several attacks of dull pain in the right flank lasting for several days.

Retrograde pyelograms showed a deformity of the right renal shadow similar to that seen in cases of renal tumor. There was no evidence of metastasis in roentgenograms of the lungs. At operation, first the abdomen was explored through a transverse incision of the abdominal wall on the right side. There were no palpable cysts in the intestines, the pancreas, the liver, the spleen or the left kidney. The large right renal mass was removed transperitoneally with the perinephritic fat attached, after ligation and division of the renal vessels. Microscopic examination revealed hemangioblastoma.

This is an unusual neoplasm of the kidney. It differs in many respects from so-called hypernephroma or carcinoma of the kidney. In the first place there is a strong tendency toward formation of capillaries. Then again there is the frequent massing of "foam cells" between hemangiomatous regions. Correlating these findings in the kidney with the clinical picture presented by the patient, Cahill, Melicow and Guerry conclude that this was a case of Lindau's disease affecting the kidney.

PRESACRAL SYMPATHICOBLASTOMA CAUSING URINARY OBSTRUCTION

Hepler [57] reports the successful treatment of a presacral sympathicoblastoma. The patient was an infant, and the tumor caused urinary obstruction at birth.

The presacral position of the tumor was of interest because sympathicoblastomas are usually primary in the adrenal medulla. However, the region ventral to the sacrum is a sort of repository or burying ground for remnants cast off in the complex embryonic development of the terminations of the intestinal tract and the central nervous system, and these remnants later may give rise to complex tumors. Included among these may be those which arise from the neurenteric canal, those from the postanal gut, the Middledorf tumors, sacral teratomas, chordomas and ependymomas.

Tumors arising from the formative cells of the sympathetic nervous system are usually primary in the adrenal medulla, but they do arise in the cervical, retropleural, retroperitoneal and sacral regions, and the histogenesis and the prognosis are the same for the extra-adrenal as for the adrenal growths.

Such a tumor was discovered filling the pelvis of a boy aged 3 weeks, who had been unable to urinate since birth. It arose from the hollow of the sacrum, compressed the urethra and displaced the bladder upward. It was partially removed through a midline abdominal incision, and the remnant disappeared after two months of roentgen treatment. There has been no recurrence during four years.

Histologic preparation showed the tumor to be malignant sympathicoblastoma. Tumors of this type are supposed to be radioresistant and highly fatal. The predominating cells were sympathicoblasts and sympathigonia, parent cells in the formation of the sympathetic nervous system. There were a few "rosettes," but otherwise there was little cellular differentiation. This fact indicates a high degree of malignancy.

The unexpected results in this case bear out Farber's contention that the prognosis is not hopeless. In his series of 40 patients 25 per cent were alive and well three to five years after the operative discovery of the tumor.

One is impressed by the unexpected results in one case of a treatment which has failed completely in another. Surgical removal followed by irradiation may fail in the treatment of a patient who has a tumor that has not metastasized and yet be successful in the treatment of another patient in whom there is demonstrable metastasis. The tumor may undergo spontaneous hemorrhage and necrosis and disappear without any other surgical intervention except biopsy. It may undergo maturation and develop into a benign ganglioneuroma. This process is comparable to the maturation which takes place in the development of the sympathetic nervous system.

Because of the unpredictable course of the process and of the response to treatment one is

57. Hepler, A. B.: Presacral Sympathicoblastoma in an Infant Causing Urinary Obstruction, J. Urol. **49**: 777-784 (June) 1943.

justified in performing as complete a surgical removal as possible, to be followed by irradiation. The irradiation should be postoperative and not preoperative. Although these tumors rarely present a problem in urologic practice except in their differentiation from embryoma of the kidney, the possibility of their extra-adrenal origin must not be forgotten.

ANESTHESIA

Hess and Merski [58] state that pentothal sodium is the ideal anesthetic agent for short and long urologic procedures. It is the safest of all. The skilled anesthetist finds it easy to administer. The patient is ready for operation in a few moments after the administration of the anesthetic agent is started and is out of anesthesia in a few minutes after the injection is stopped. He is comfortably drowsy the rest of the day.

This anesthetic agent can be used under all operative conditions, since it is nonexplosive, and it can be given time after time without any ill effects.

The pulse rate and the blood pressure are not influenced by pentothal sodium. If anything, it seems to improve the action of the heart in some of the cases in which concern is felt because of a damaged myocardium. The one danger is sudden respiratory failure. The antidotes for respiratory failure are oxygen, picrotoxin, coramine (a 25 per cent solution of pyridine beta-carboxylic acid diethylamide), metrazol and aromatic spirit of ammonia U. S. P.

Hess and Merski state that pentothal sodium in their hands has proved so safe that they consider it the best general anesthetic agent for all surgical purposes.

58. Hess, E., and Merski, A. T.: Some Observations in the Use of Pentothal-Sodium, Urol. & Cutan. Rev. **46**:709-713 (Nov.) 1942.